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ENGINEERING AND MINING JOURNAL-PRESS

A CONSOLIDATION OF ENGINEERING AND MINING JOURNAL AND MINING AND SCIENTIFIC PRESS

The New Copper Queen Concentrator
Its Equipment and Results Obtained
By Ernest Wittenau

Technical Developments in Copper Smelting
By Edward H. Robie

Marketing Tantalum Ores and Metal
By David Taylor

The Critical Line of Drilling in Oil-field Development
By S. H. Brockunier

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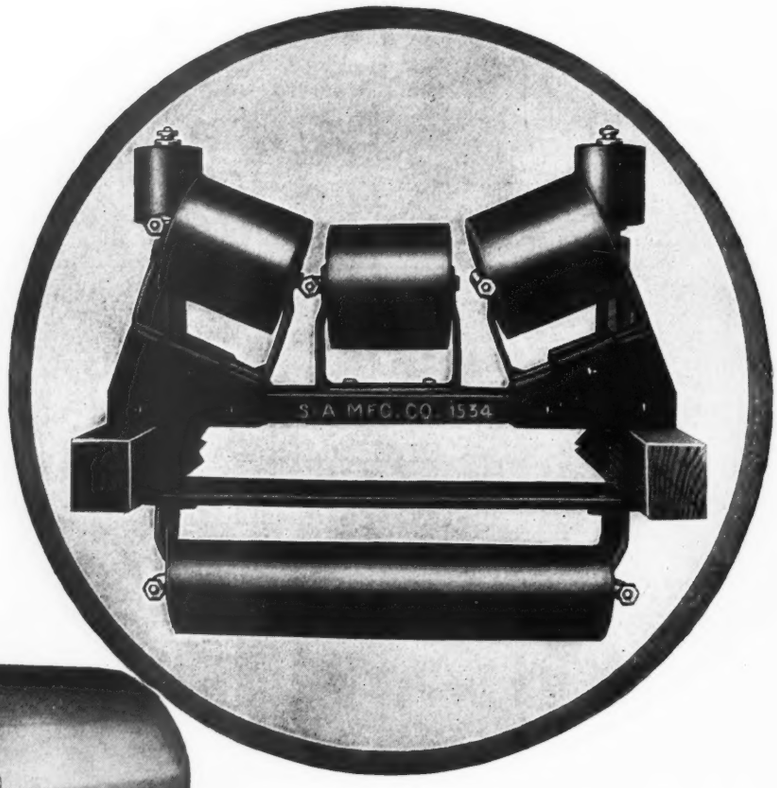

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ENGINEERING AND
MINING JOURNAL-PRESS

JOSIAH EDWARD SPURR, Editor

Volume 117 New York, May 24, 1924 *Number* 21

Evolution

THE BEGINNING OF THE WORLD—the cooling of the globe—the breaking down of the elements into simpler substances—these are the most fascinating and romantic of all contemplations. In a recent paper on "The Evolution and Disintegration of Matter," published by the U. S. Geological Survey, Prof. F. W. Clarke gives a clear and brief résumé of current thought and hypotheses on these and kindred subjects, distinguishing adequately between the established and the assumed. Professor Clarke refers to his suggestion in 1873 that the evolution of the chemical elements accompanied the evolution of planets from nebulæ; and sketches further discoveries and thought to the present day. The planetary nebulæ, as shown by their spectra, consist of hydrogen, helium, and nebulium (an element not known in the earth), with slight traces in some of them of carbon and nitrogen.

A theory to account for the evolution of the stars has been arrived at by astronomers. After the gaseous nebulæ come the blue stars. These show the transition from a mainly hydrogen-helium composition to those showing considerable magnesium and calcium, and beginnings of iron, titanium, oxygen, silicon, and nitrogen. These pass to the bluish-yellow stars, and these to the yellow stars, the change being accompanied by a further decrease of hydrogen and increase of the metals (as shown by the spectra). The change goes on to the reddish-yellow stars, and these to the red stars, with the same tendency of change in composition, the last stage showing a large metallic percentage, together with conspicuous bands of carbon oxides. All this progressive change from the nebulæ to the red stars is believed to represent a progressive generation of the elements from the original hydrogen-helium (nebulium) world-stuff, this generation being made possible by cooling. A still greater degree of cooling took place before the elements could group themselves into molecules and compounds.

Turning now from astronomical to chemical evidence, it is pointed out that the two elements indicated by astronomy as the oldest (hydrogen and helium) also have the lowest atomic weight and therefore are the simplest, hydrogen having been generally used as the unit to which to refer atomic weight; and the elements are thus grouped in the order of their weight, up to the heaviest, uranium, with an atomic weight about 238 times that of hydrogen. On the theory of evolution of the elements, uranium would also be its most complex element. Indeed, that it is resolvable into component elements has been known for years. The first proof of the divisibility of the elements was the discovery in 1903 of the emission of helium from radium—of one "element" from another. Later it was found that uranium is slowly decaying, forming radium and eventually lead; while thorium is also similarly decaying and also producing, eventually, lead. The total time for the decay of these "elements" is enormous, the half-life of uranium, for example (the time required for it to lose half its substance), having been calculated at 4.67×10^9 years. Attempts have been made also to disintegrate other elements, with some tangible though faint promises of success.

Coming down to the molecular compounds of the elements, they are believed to be a later stage of evolution from that of the elements, and to have appeared first in a cooling globe such as the earth. This evolution of compounds, taking place simultaneously with the operation of gravitational energy, gave our earth a heavy metallic nucleus, surrounded by a zone of silicates. Thereafter, the evolution of more and more complex chemical compounds proceeded, becoming most complex in the field of organic chemistry, and more complex in higher organisms than in lower ones.

Meteorites are considered by Professor Clarke to yield us actual samples of the stuff from which the interior of the earth is made—they consist largely of nickel-iron, in part of stone which averages essentially a peridotite, or olivine rock. Other celestial minerals are augite, enstatite, anorthite, chromite, diamond, and hydrocarbons.

It is believed by Professor Clarke that the outer zone of the earth—the lithosphere—consists of three rough layers: the siliceous igneous and sedimentary rocks on the outside; basalt beneath; and, still lower, the layer corresponding to the average of meteoric stones. Below all this is the central nucleus of nickel-iron. The moon has the average density of the meteoric stones, and therefore is supposed to have been thrown off essentially from that layer of the earth. The diameter of the nickel-iron nucleus of the earth Professor Clarke puts at around 6,200 miles; of the envelope (including the three divisions above stated) about 900 miles. The temperature of the metallic interior is considered to be below 1,600 deg. C.

These are intensely interesting views, supported as they are by a great array of facts and clear-sighted deductions. To the student of ore-science, the restriction of the metallic nucleus to the nickel-iron alloy is not so exciting as the equally venerable view, recently supported by Dr. H. S. Washington, that the metallic nucleus contained the different metals, arranged according to their specific gravities, like the layers of an onion; but it is more in accord with the celestial evidence derived from meteorites. Yet the mind instinctively hovers between these two views of two distinguished geochemists; for while we have great concentrations of nickel at the earth's surface, we also have similarly great concentrations of lead and zinc and tin and copper and other metals. Professor Clarke's explanations do not enlighten us as to the possible telluric local concentration (metallographic provinces) of other metals than iron and nickel. The phenomena of extensive rectilinear ore channels or ore canals pointed out by Spurr in 1923 seems to indicate the concentration of metals other than

iron and nickel at some zone beneath the superficial crust—beneath that portion affected by magmatic and isostatic adjustment.

The paper of Professor Clarke which we have been discussing is a splendid and welcome contribution, eloquent of the vitality of the venerable and distinguished scientist.

Romance of Fraud in Mining Enterprise

WESTERN AUSTRALIA, by reason of the richness of the deposits of gold ore at Coolgardie and Kalgoorlie, has contributed many interesting episodes to the romance of fraudulent promotion, gold stealing, and the operation of fake mines; and divers tales are told of the doings of crooked gentry who infested the region in the hectic days of boom. In spite of precautions, stealing was rampant. Bogus assay offices were opened in which business was done ostensibly in purchasing slag and mill refuse; but the gold reported as coming from legitimate business really came from thieves. In one instance it was discovered that a partnership existed between a baker and one of the so-called assayers, who possessed a small reduction plant. The baker delivered bread to the gold stealers and received, when on his rounds, the purloined ore. This was deftly concealed in loaves and delivered to the assayer.

A few enterprising parties went further, staked out claims, sunk shafts in the ground and erected small mills to treat the ore supposed to have been discovered. Others purchased a worked-out claim and plant; regular returns were made through the proper channels, and no suspicions were aroused until the game was given away; whereupon the mine was raided, to disclose the fact that there was no ore in sight. Waste rock was milled, stolen rich ore was added, and excellent returns were made from the mixture. This system, known as the dummy-lease fraud, was one of the most difficult matters with which the authorities had to deal; it was wellnigh impossible to prove that the returns from such a mine were fraudulent, and that the reported yield of gold indicated a figure that had been augmented by illicit trafficking in stolen ore.

Recently, an alleged discovery of oil in Western Australia resulted in the arrest of two individuals whose efforts to fleece the unwary were exposed by a government official. A lease in the desert was pegged out in the usual manner, a borehole put down, and oil "discovered" at 30 ft. Excitement reigned until a plot to defraud was uncovered, a critical examination of the surroundings revealing the fact that the oil had been made to flow into the borehole from an adjoining chamber, which had been carefully mined and timbered. In this chamber was arranged a tank, connected to the surface with a pipe, into which the oil was delivered. Another pipe connected the tank and the borehole, fitted with a long-spindle valve that was operated by twisting one of the legs of the table in the tent occupied by the conspirators. The flow of oil into the borehole could thus be controlled to a nicety, and wastage prevented when investigators or suckers were not in the vicinity. Unfortunately for the conspirators, the evidence arranged was viewed with considerable suspicion by petroleum geologists, and an investigation resulted in the exposure of the fraud.

Changes in Open-pit Mining

RELATIVELY FEW changes have taken place in open-pit mining methods and equipment. The recent move of the Utah Copper Co. in equipping its steam shovels with caterpillar tractors is, however, in the nature of an improvement, for it releases the pit laborers required in the usual steam-shovel operations and greatly increases the mobility of the shovel and lessens the track work. Other companies have provided similar equipment for their steam shovels. Utah Copper has also purchased two electrically operated shovels and plans ultimately to change its present steam-shovel equipment to electrically operated shovels. The situation at present involves the operation of a number of isolated units that require water and fuel service, inspection, and field and shop repairs, as well as entailing no little boiler trouble. By the substitution of electrically operated units a greater power efficiency will be secured, boiler trouble eliminated, and water and fuel service rendered unnecessary. In addition, the present 3½ cu.yd. buckets with which the shovels are equipped are to be changed to 4½ cu.yd. buckets, thus increasing the capacity of each unit.

The changes indicated will reduce the number of labor units and increase the power efficiency and output, resulting in an all-round economy of no little magnitude. In the annual report of the company it is stated that the improvements adopted will result in an efficiency of about 12 per cent over the existing steam-shovel equipment. During 1923, an ore tonnage of 11,167,800 and 2,517,025 cu.yd. of stripping was handled. Unit costs were 20.16c. per ton of ore and 49.78c. per cu.yd. of capping. The unit costs with the new equipment will be awaited with interest.

Undoubtedly, the changes enumerated will involve a large capital expenditure, the carrying of which will appreciably reduce the direct saving, but the expectant life of the property is such as to warrant the additional investment. What is of greatest interest to the open-pit miner is the influence that this installation will have upon the selection of the mechanical equipment for new work. Very likely electrical power distribution and electrically operated shovels will tend to displace the steam shovel where the quantities produced entail a number of separate units.

Power a Topic for British Engineers

IT IS NATURAL that with the approach of the World Power Conference, to be held in London this July, British engineers of all kinds should be turning their attention to the subject of power and power plants. Not fewer than 282 papers on these and kindred topics are on the conference program, so a little furbishing and refreshing of one's knowledge of the fundamentals will be excellent preparation for the big occasion.

Power developments was the theme of William H. Patchell, president of the Institution of Mechanical Engineers, when, on March 21, he delivered his presidential address to his British audience. His experience, reaching back to 1862 and covering the enormous growth of the power industry since that time, gave point to his observations on the extraordinary changes now taking place. More recently, on April 10, the newly elected president of the Institution of Mining and

Metallurgy, Humphrey M. Morgans, took the subject of power plants for his presidential address, at the same time expressing the hope that he would not be judged too venturesome or as outstepping the bounds. Realizing that he was not talking to a group of specialists in the power field, as was Mr. Patchell, he did not deal with the extraordinary but with conditions likely to occur in the experience of the mining men and metallurgists before him. Dividing his subject into four parts —fuels, steam plant, oil plant, and gas plant—Mr. Morgans presented his subject in admirable fashion. So excellent an outline of his topic was his speech, with its terse comment, that it could readily be expanded into an up-to-date textbook on the subject of modern power-plant equipment and practice—written, it should be remembered, from the British viewpoint.

The various fuels and the fields for their use; the forms of boilers and of steam-, oil- and gas-driven prime movers in common use; their usual range in size and horsepower, their performance, limitations, and advantages, and their accessories—all these topics, with running comment on operation, preferred practice, and the like, were covered by the speaker. Truly an unusual inaugural address for the president of the Institution, but notable and timely. It will help create the proper atmosphere for the approaching conference.

Tin and the United States

ONE REASON why the world does not progress at a breakneck speed is because of the fundamental dullness of the masses. In Zion, Illinois, the world is still considered flat, and the whale is still regurgitating Jonah. This extreme example is illuminating. We once heard the chairman of the Ways and Means Committee of the House of Representatives of the United States of America say that whereas formerly America produced practically no tin, when Yankee pluck and ingenuity got to work they soon produced not only all the domestic tin required, but exported largely to the outside world. Some intrepid witness, unable to stand the strain, suggested that the chairman meant tin-plate instead of tin; but the chairman didn't seem to grasp the difference.

That there is practically no tin in North America is still news—and discredited news in some quarters. For that reason it is well to mention the recent report by the sub-committee on tin, of the Committee on Foreign and Domestic Mining Policy, of the Mining and Metallurgical Society of America. This report is signed by G. Temple Bridgman, H. H. Alexander, and posthumously for our lamented friend, A. R. Ledoux.

Says the report:

"Our scanty tin occurrences have been exhaustively studied by engineers, and by our state and national surveys, for some forty years; attempts without number have been made commercially to exploit certain of these deposits; and there is perhaps no form of mining in this country in which so great and continuous an investment has been made with such a universal lack of return. If patience, capital, or brains could have given us a tin mine, under the commercial conditions which have existed, we would have had it."

Of the South Dakota tin occurrences the committee says:

"It is probable that the tin occurrences of South Dakota have attracted more attention than any others in this country. They have been recognized since 1883; have been examined, tested, and reported upon by engineers from all over the world; have been studied again and again by the Survey; and have formed the basis for very great expenditures in attempted exploitations. So far, the tin yield has been negligible.

"The most important occurrences in this state are probably those in the neighborhood of Harney Peak, in the southern Black Hills. . . . Various engineers have made estimates of an average grade of considerably over 1 per cent. Experience, however, has not confirmed the accuracy of such estimates. At the chief 'mine' of the district, where a very ambitious investment has been made and a large mill installed, several thousand tons of ore yielded only about 0.25 per cent tin—and it seems improbable that an average grade of over 0.50 per cent could be reasonably hoped for. Of such material, however, a considerable total tonnage could apparently be secured."

From all tin prospects in the United States a theoretically conceivable maximum production of 6,000 tons of metallic tin a year is estimated, as against the United States requirement of 70,000 tons:

"This maximum production of 6,000 tons per year, which is far above anything which any conceivable legislation could actually make possible, is still less than 10 per cent of the 70,000 we are going to need. Unless, therefore, we surrender our tin consuming industries, virtually in their entirety, we are still going to get 90 per cent of our tin from other nations."

The committee summarizes the situation unmistakably as follows:

"Our tin resources do not constitute potential infant industries; they are not on that middle ground where protection can bring them into being. They are simply, for all practical purposes, non-existent. And, as we now see the matter, no legislation can create them."

As to the future supply of tin, a gradual world scarcity—not to say famine, but a growing hunger, at least —of tin is evident. Says the committee:

"During the past decade, tin consumption has continuously increased without any relatively important new developments—all of which has been reflected in a gradual upward price trend. The present sources of production are not inexhaustible; and, unless there is to be a tin scarcity, there must be new discoveries and new developments."

The committee points out that the consumption of tin is by the great industrial countries; the United States consumes 60 per cent of the world's production, and Europe practically all the rest. But Nature has so arranged it that the main supplies come from non-industrial regions of the globe. The estimated world production of 125,000 tons of tin annually for the next few years will come principally from the Dutch East Indies and Malaya (63,000 tons); next from Bolivia (33,000 tons), with practically all of the remainder from Asia and Africa, except 2,500 tons from Australia and 2,000 tons from Cornwall.

If we may put it more epigrammatically, the United States demands 60 per cent of the world's production, and produces nothing, while Asia produces more than 60 per cent, but demands little for her industries. It is inevitable, therefore, that future development of new mines will be accomplished by capital from North America and from Europe.

The natural conditions, the committee believes, demand freedom for exploitation and investment by the industrial nations in any quarter of the globe where tin occurs, and adds:

"It is interesting and reassuring to note, that, so far as tin is concerned, this freedom of exploration and possession already exists in all countries, except China and Burma, which are known to contain commercial tin fields."

The New Copper Queen Concentrator

Equipment and Results Obtained

Three Units Doing the Work Originally Planned for Four, Making 92 Per Cent Recovery on 2 Per Cent Ore—No Ball Mills Used

By Ernest Wittenau

Concentrator Superintendent, Phelps Dodge Corporation, Bisbee, Ariz.

Ernest Wittenau

THE PURPOSE of this paper is to present briefly the results obtained during the first year in the treatment of a low-grade sulphide ore in the Copper Queen concentrator of the Phelps Dodge Corporation at Warren, Ariz. The first section of the concentrator was completed and put in operation on April 2, 1923. The mill, designed by H. Kenyon Burch, was built to treat the ore from Sacramento Hill, in Bisbee; this ore assays about 2 per cent total copper and 0.12 per cent acid-soluble copper.

Open-pit mining was decided upon for the Sacramento Hill ore, steam shovels being employed to remove the barren capping from the orebody and the broken ore from the pit. The method of mining influenced the flow sheet adopted for the concentrator crushing plant only, to the extent that an additional coarse breaker was installed at the concentrator immediately preceding the usual form of coarse breaker for run-of-mine ore from underground workings.

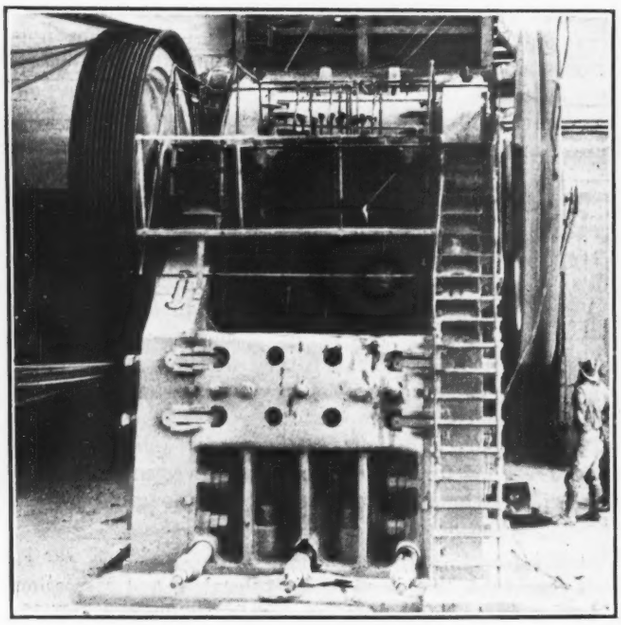
The general scheme of crushing and milling at the concentrator will first be outlined briefly, followed by a summary of the results obtained.

The coarse-crushing department is a rigidly constructed plant of steel and concrete. The tops of the steel columns are tied and the roof is supported on box-type steel girders. The length of the plant (in the direction of the flow of the ore) from back of ore delivery track to lower wall is 176 ft. 7 in. This length is made of the following bays:

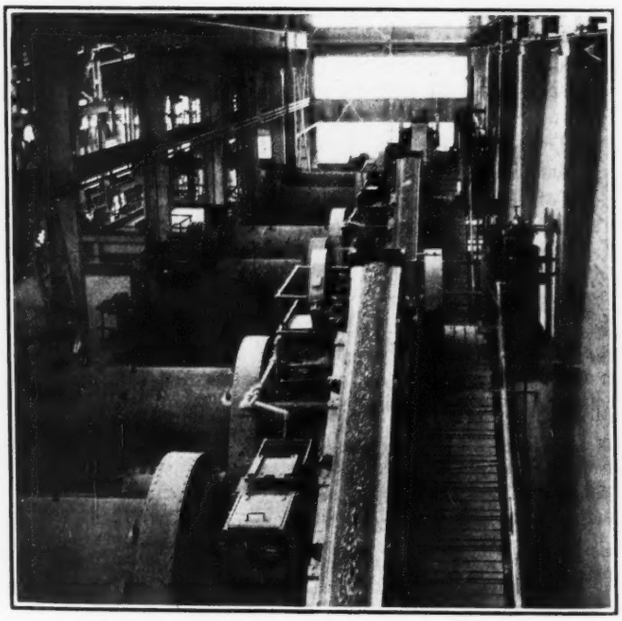
Number	Length	Width	Covers	Crane Type	Service Capacity
1	24 ft. 7 in.	40 ft.	Delivery track and grizzly	None	None
2	36 ft. 5 in.	40 ft.	Primary breaker	Travel	40 tons
3	36 ft. 1 in.	40 ft.	Motor for primary Breaker and surge bin	Trolley	10 tons
4	42 ft. 6 in.	60 ft.	Gyratory crushers	Travel	20 tons
5	37 ft. 0 in.	80 ft.	Disk crushers	Travel	20 tons

The ore from the pit is hauled directly to the concentrator crushing plant in trains of five cars, each car having a capacity of between forty and fifty tons and being of the side-dump type. These cars dump directly onto a grizzly inclined from the side of the track at 45 deg. and deliver the oversize product directly into the mouth of the jaw crusher. The grizzly is made up of steel I-beams spaced 8 in. apart, the beams being surmounted by half-circle removable caps to take up the wear, the grizzly oversize passing through an 84x66-in. all-steel Allis-Chalmers jaw crusher, to be crushed to 8 in. and to join the undersize product.

The crusher runs at a speed of 120 r.p.m. and is driven by a 250-hp. motor. Power is transmitted from



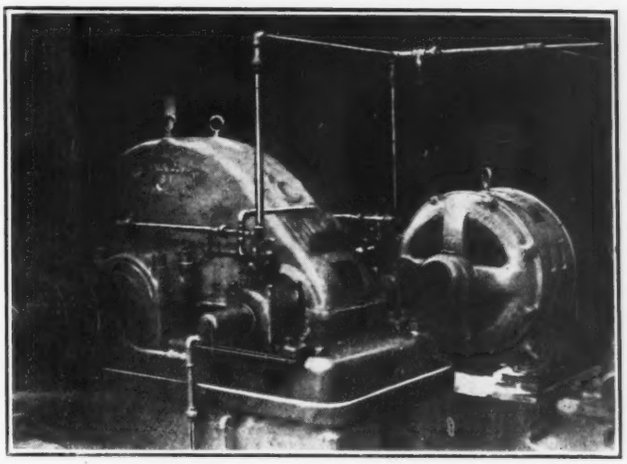
The giant 66x84-in. jaw crusher



Primary rod mills, with belt conveyors

the motor to the crusher by means of twelve 1¼-in. ropes, English drive. Both the product from the jaw crusher and the undersize from the grizzly are conveyed to a 1,000-ton surge bin by two 54-in. pan conveyors, 61 ft. long from center to center. The ore is taken from this surge bin by four 48-in. apron feeders, 6 ft. long, and drops onto two 48-in. belt conveyors, 34 ft. long from center to center, by which it is conveyed to two ring grizzlies, which separate it at a 4-in. size, the oversize passing through to two No. 9 Gates gyratory crushers, then joining the undersize of the grizzlies. The total undersize and crusher product drops onto two 36-in. belt conveyors, 38 ft. long from center to center, by which it is conveyed to four ring grizzlies, which separate it at 1¼-in. size, the oversize passing through four Symons 48-in. horizontal disk crushers to be crushed to 1¼-in. size to join the undersize of the grizzlies. This undersize and crusher product constitute the finished product of this department. There are two 30-in. diameter by 38-in. face Dings magnetic head pulleys ahead of the Symons disk crushers, one ahead of each pair.

The crushing plant runs two shifts to accommodate the two-shift steam-shovel operations, and handles 4,000 dry tons of run-of-mine ore to 1¼-in. size in sixteen hours with an ample margin of time to spare. The finished product of the plant is removed by a 42-in. inclined conveyor belt, 320 ft. center to center, which

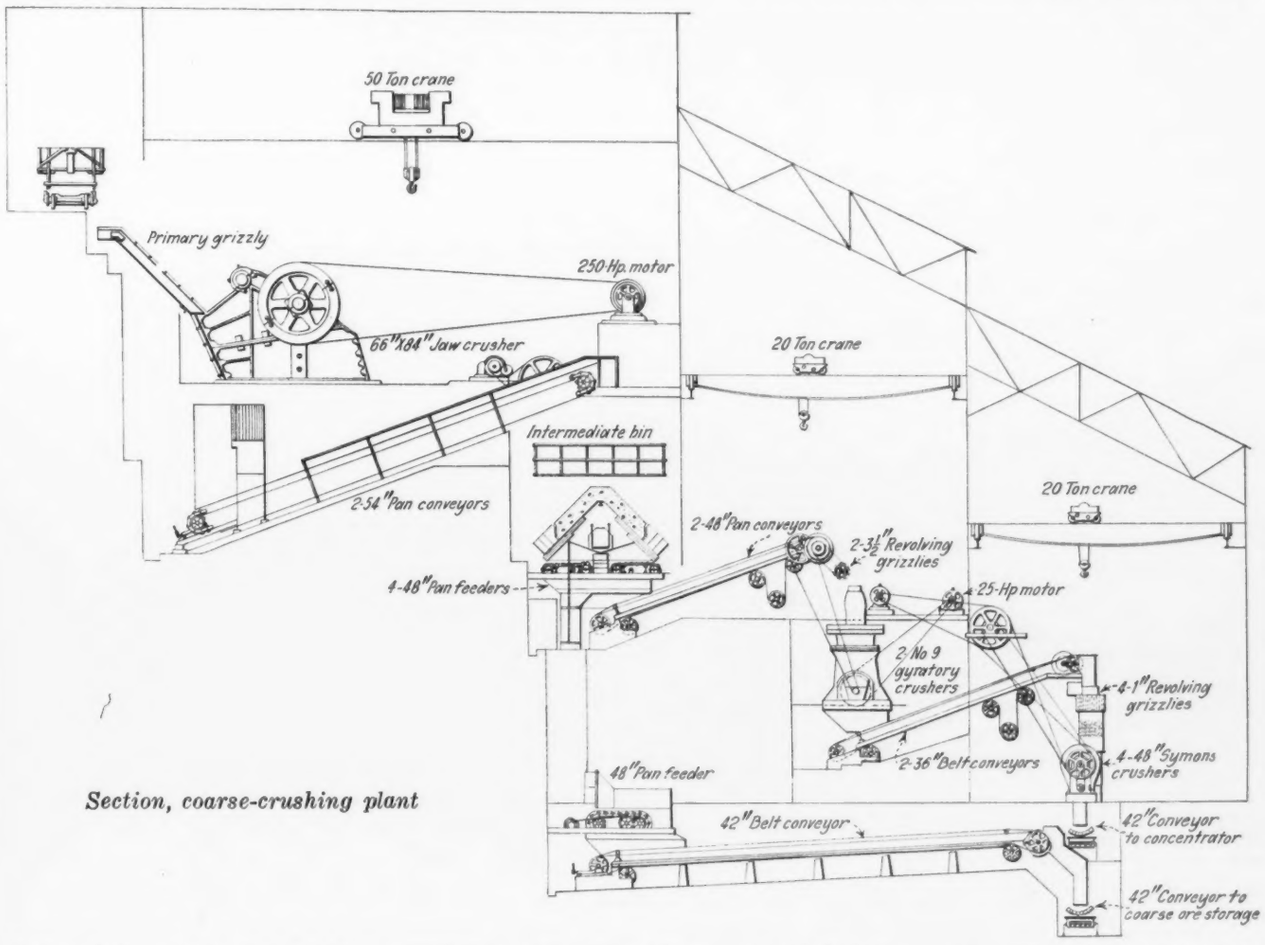


Gear reduction drive for rod mills

may be crushed to 8-in., 4-in., or 1¼-in. size. So far all of the ore crushed for the smelter has been 1¼ in.

The crusher plant is equipped with a Lynch dust-collecting system, which delivers practically all of the collected dust to the fine-ore bins.

The ore from the coarse-crushing plant is received in a rectangular concrete bin 49 ft. from back to front, 216 ft. long, and 32 ft. deep at the front. The back half of the bin bottom is rock-surface sloped at 45 deg.;



Section, coarse-crushing plant

in turn delivers it to the shuttle conveying system over the fine-ore bins at the head of the concentrator.

The plant is also equipped with a special delivery and bin system, so that ore intended for direct smelting the front half is flat concrete. The length of the bin is the width of the operating part of the concentrator. The capacity of the bin is 12,000 tons of dry crushed ore. Discharge openings are in a straight line down

Metallurgical Data for One Month's Operation

	Dry Tons	Assay Per Cent: Total Cu	Acid Soluble Cu	SiO_2	Fe	S	Al_2O_3	MgO	CaO	Tonnages: Cu	Acid Soluble Cu	SiO_2	Fe	S	Al_2O_3	MgO	CaO
Mill feed	125,579	2.09	0.11	67.2	8.2	8.4	8.4	0.1	0.1	2,624.60	138.14	84,389	10,297	10,549	10,549	126	126
Concentrate																	
Primary	17,355	6.60	0.19	23.8	28.8	33.4	1.9	0.2	0.4	1,145.04	32.97	4,130	4,998	5,797	330	35	69
Flotation	9,438	12.75	0.29	15.0	27.1	34.6	5.1	0.2	0.2	1,203.34	27.37	1,416	2,558	3,266	481	19	19
Finish tables	1,238	4.95	0.34	25.6	32.5	25.5	3.2	0.2	0.3	61.31	4.21	317	402	316	40	2	4
Total	28,031	8.60	0.23	20.9	28.4	33.5	3.0	0.2	0.3	2,409.69	64.55	5,863	7,958	9,379	851	56	92
Tailing	97,548	0.22	0.08	80.5	2.4	1.2	9.9	0.1	0.1	214.91	73.59	78,526	2,339	1,170	9,698	70	34

Dry Tons Ore Concentrated

Operating Days in Mill	Days Run	Per Cent Total	Days Lost	Per Operating Day	Per 24 Hours, Running Time	Concentrate Produced: Per Operating Day	Per 24 Hours, Running Time
30	28.85	96.17	1.15	4,186	4,353	934	972

Percentage Extraction

	Sulphide Copper	Total Copper	Ratio of Concentration
Feed and tailing	.....	91.82	.....
Feed and concentrate	.....	91.85	.....
Analysis	94.89	91.82	4.48 into 1

Gallons of fresh water used per ton of ore milled, 258.
Kw.-hr. per ton of ore milled, 11.99.
Note—Silica pulled on roughing tables to make a self-fluxing concentrate for the smelter.

Power Data

Crushing and Conveying	Kw.-hr. at Power House	Per Cent of Total	Kw.-hr. per Ton of Ore Milled
Jaw crusher	19,611	1.30	0.16
Gyratory crushers	13,776	0.92	0.11
Disk crushers	28,787	1.91	0.23
Conveyors for all classes of ore	10,179	0.68	0.08
Concentrator conveying system	42,181	2.80	0.33
Smelter conveying system	233	0.01	0.00
Dust collecting system	10,847	0.72	0.09
Total crushing and conveying	125,614	8.34	1.00
Concentrator			
Primary grinding	439,335	29.19	3.50
Secondary grinding	444,435	29.52	3.54
Roughing tables	14,649	0.97	0.11
Finishing tables	17,166	1.14	0.14
Flotation	278,374	18.49	2.22
Coarse concentrate handling	27,314	1.81	0.22
Fine concentrate handling	52,574	3.49	0.42
Mill water	94,113	6.25	0.75
Mill shops	950	0.06	0.01
General mill expense	541	0.05	0.00
Assaying and sampling	10,235	0.69	0.08
Total crushing plant and concentrator	1,505,300	100.00	11.99

Concentrate Produced

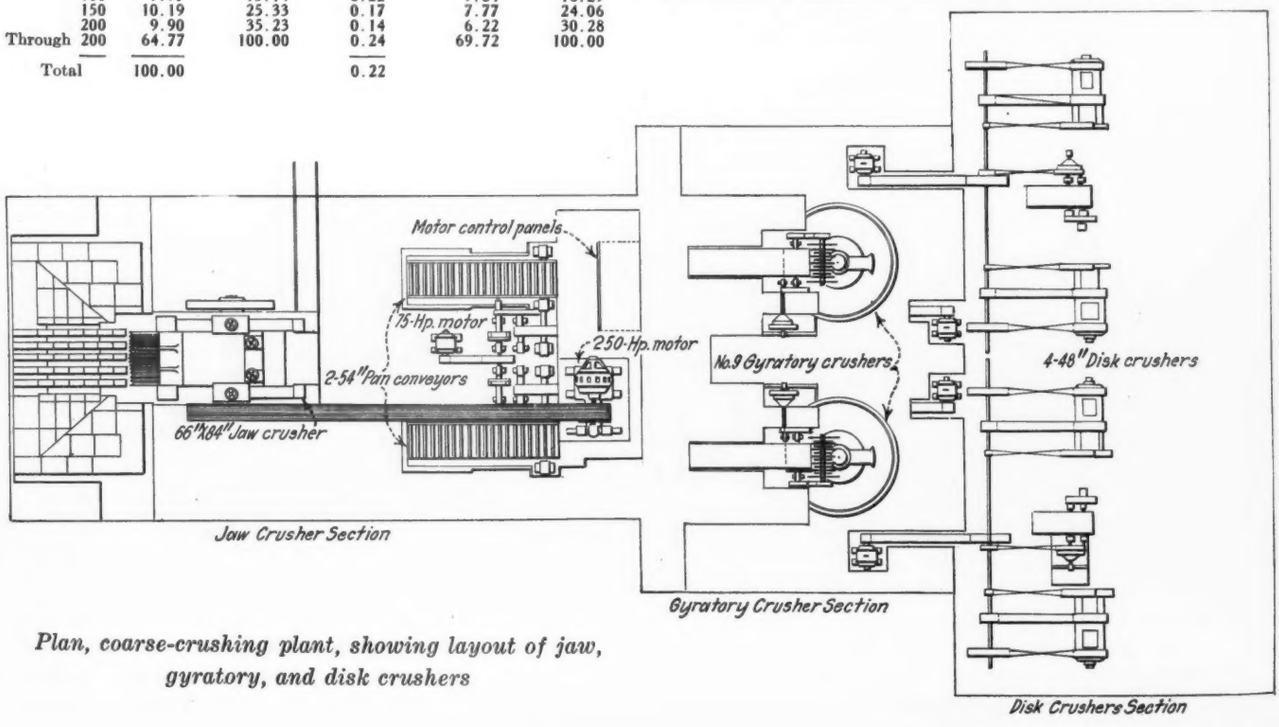
	Assay Per Cent Cu.	Assay Per Cent Insoluble	Per Cent H_2O	Per Cent Total Dry Weight	Per Cent Total Copper
Primary tables	6.60	25.7	5.00	61.91	47.52
Flotation	12.75	20.1	14.88	33.67	49.94
Finish tables	4.95	28.8	5.00	4.42	2.54
Total	8.60	23.9	7.70	100 00	100.00

Screen Analysis of the General Tailing

	Mesh	Weight: Per Cent	Cumulative Per Cent	Per Cent Copper	Copper Content: Per Cent	Cumulative Per Cent
Plus	48	1.46	1.46	0.35	2.29	2.29
	65	3.71	5.17	0.25	4.16	6.45
	100	9.97	15.14	0.22	9.84	16.29
	150	10.19	25.33	0.17	7.77	24.06
	200	9.90	35.23	0.14	6.22	30.28
Through	200	64.77	100.00	0.24	69.72	100.00
Total		100.00		0.22		

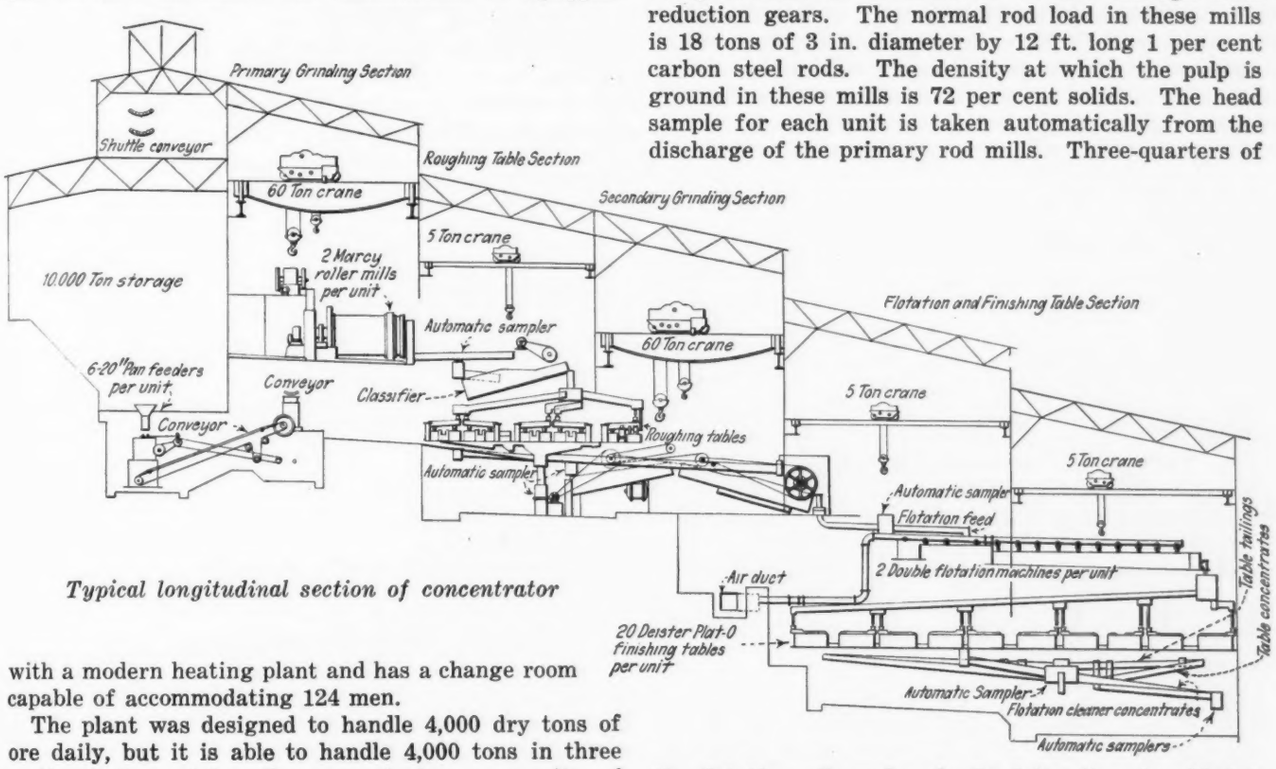
the center of the bin lengthwise and are twenty-four in number, six to each concentrator unit. For the feeding of one unit, ore is drawn from the storage bin on six 20-in. apron feeders which are driven through Foote worm-gear reducers. The ore to each unit is weighed by means of a Merrick belt scale on the conveyor belt feeding the primary rod mills. The total ore is also weighed on the conveyor going from the crushing plant to the fine-ore bins.

The concentrator is a well-constructed building of steel and concrete, exceptionally well lighted, and designed so that all operations can be surveyed easily. The walls of the building are of galvanized corrugated iron and the roof is of 4-ply Mansville asbestos roof covering laid on a 2-in. redwood sheathing. All inside steel work is finished with white or black enamel paint.



Plan, coarse-crushing plant, showing layout of jaw, gyratory, and disk crushers

Crane service of the required capacity covers all equipment, ranging from 5-ton cranes over flotation cells and tables to 60-ton cranes with 10-ton auxiliary hoist over the grinding mills. A well-equiped machine shop is placed adjacent to the mill floor, with which it is connected by crane service, and an inclined hoistway also serves each floor. The concentrator is equipped with a modern heating plant and has a change room capable of accommodating 124 men.

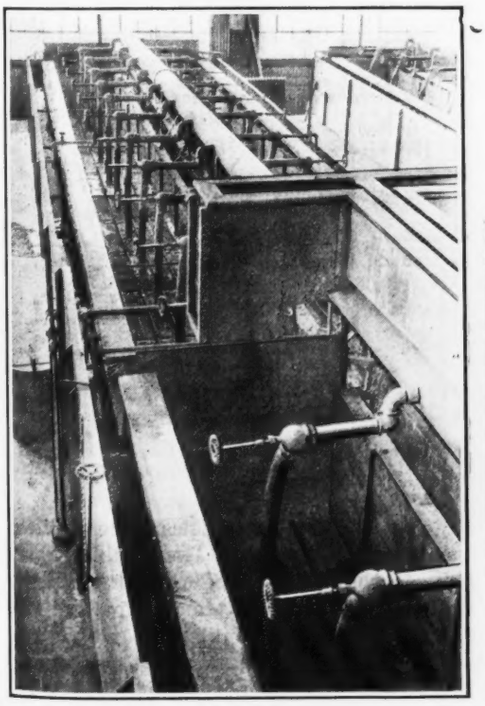


Typical longitudinal section of concentrator

The plant was designed to handle 4,000 dry tons of ore daily, but it is able to handle 4,000 tons in three sections, thus giving the concentrator a capacity of 5,200 dry tons of ore a day, although up to now only three sections have been operated at any one time. As all four sections are the same, a description of only one will be given.

The ore from the storage bins is delivered to two 6 ft. 6 in. by 12 ft. 3 in. primary Marcy rod mills, which reduce it in one pass to minus 14 mesh. A 2-in. wood backing is placed underneath the mill liners, so that when the mill is fully lined its net dimensions are approximately 5 ft. 10 in. by 12 ft. Each mill is driven at the rate of 17½ r.p.m. by a 150-hp. motor, power being transmitted from motor to mill through Falk reduction gears. The normal rod load in these mills is 18 tons of 3 in. diameter by 12 ft. long 1 per cent carbon steel rods. The density at which the pulp is ground in these mills is 72 per cent solids. The head sample for each unit is taken automatically from the discharge of the primary rod mills. Three-quarters of the flotation oil used and all of the lime is added in these mills.

The product from these mills is sent direct to ten Plat-O roughing tables, which separate it into a clear granular concentrate and a middling, which requires regrinding for treatment in the flotation system. Each



To the left is shown one of the concrete flotation cells, with the method of piping the air. Below are some of the cell bottoms in various stages of assembly

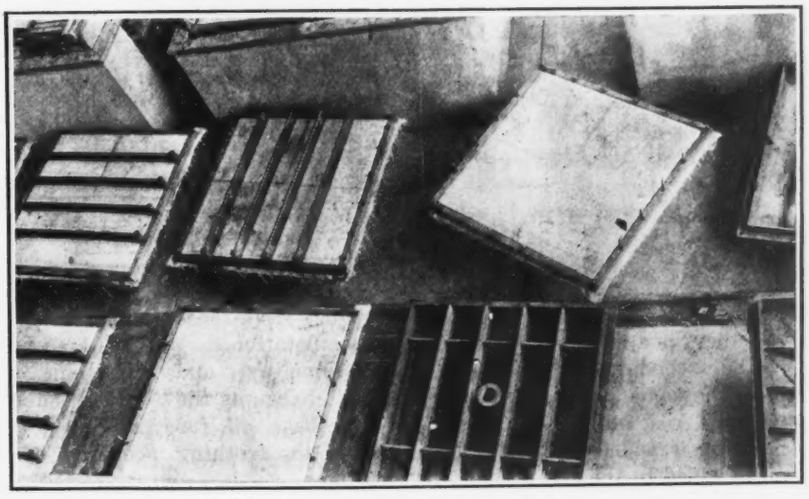
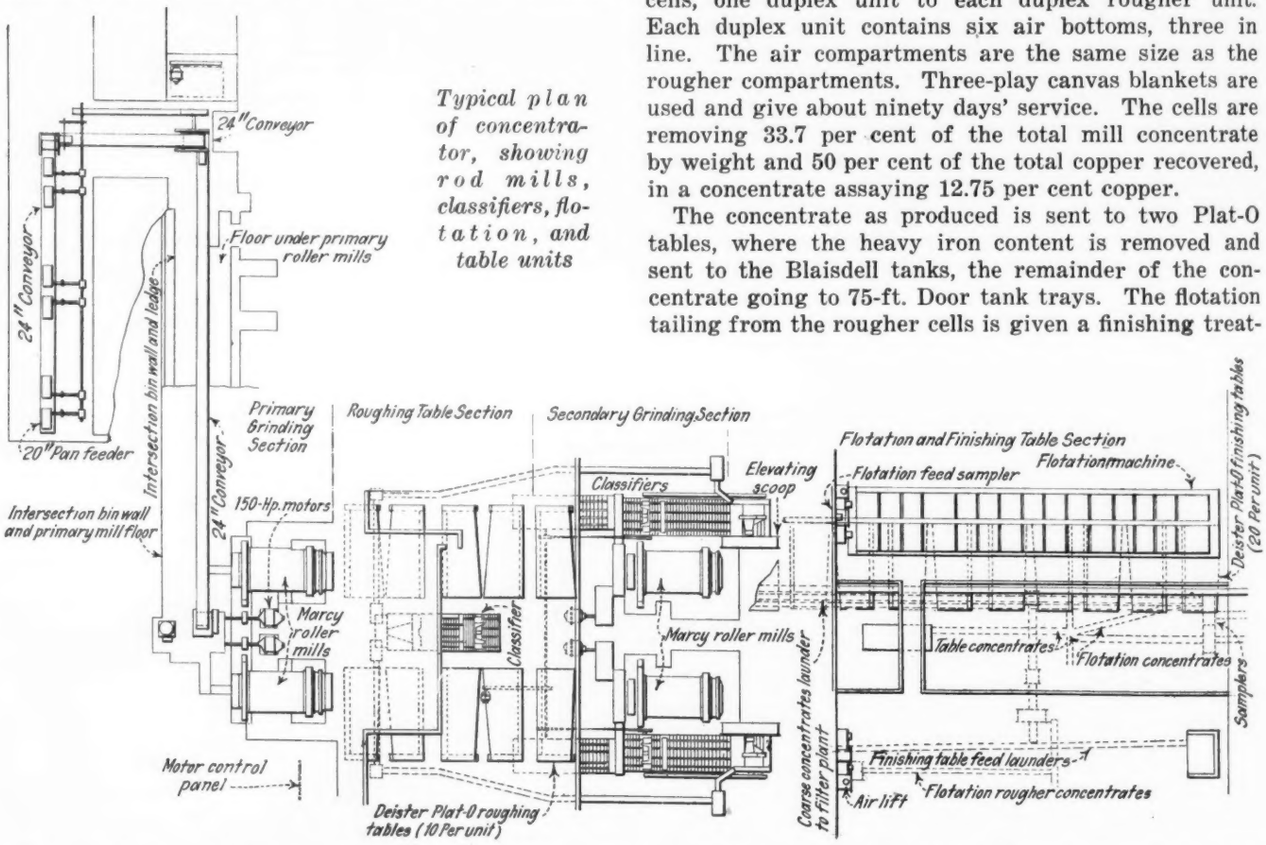


table is handling 140 tons per twenty-four hours. Individual Westinghouse induction motors, 1 hp., are employed, driving the table through gear reductions, at 275 r.p.m. These tables are removing 61.9 per cent by weight of the total concentrate recovered and 47.5 per cent of the total copper recovered, in a concentrate

	Feed		Discharge	
Mesh	Per Cent By Weight	Cumulative Per Cent By Weight	Per Cent By Weight	Cumulative Per Cent By Weight
Plus 1½ in.	8.75	8.75	.....	.....
1 in.	7.43	16.18	.....	.....
¾ in.	16.36	32.54	.....	.....
½ in.	12.99	45.53	.....	.....
3	17.52	63.05	.....	.....
4	6.76	69.81	.....	.....
6	5.22	75.03	.....	.....
8	4.08	79.11	.....	.....
10	3.76	82.87	.....	.....
14	2.38	85.25	.....	.....
20	2.64	87.89	7.67	7.67
28	2.06	89.95	7.36	15.03
35	2.21	92.16	11.66	26.69
48	1.46	93.62	9.05	35.74
65	1.17	94.79	7.82	43.56
100	1.44	96.23	9.51	53.07
150	1.01	97.24	7.05	60.12
200	0.77	98.01	5.98	66.10
—200	1.99	100.00	33.90	100.00
Total	100.00		100.00	

assaying 6.6 per cent copper. The concentrate, as produced, is sent to Blaisdell excavator tanks by an air lift. The middling is dewatered in two 4 ft. 6 in. by 8 ft. Dorr classifiers and reground in two 6 ft. 6 in. by 12 ft. 3 in. secondary rod mills, which operate in closed circuit with two 6x23-ft. Dorr classifiers, classification being assisted by the addition of the overflow



Typical plan of concentrator, showing rod mills, classifiers, flotation, and table units

from the first classifiers. The final product from these classifiers is a minus-48-mesh overflow for flotation.

The secondary rod mills are of the same size, and have the same motor equipment and rod charge as the primary rod mills. One-fourth of the base oil for flotation is added in these mills and all of the frothing oil is added to the second classifier overflow.

The flotation system consists of two rougher cells 42 ft. long by 10 ft. wide and two cleaner cells 12 ft. long by 10 ft. wide. Two products are obtained in this department, a cleaner concentrate, which is sent to 75-ft. Dorr thickeners and a middling, which is treated on finishing tables. Each unit contains twenty-two air bottoms, eleven in line in each cell. The air compartments are 3 ft. 6 in. square, giving a total area of porous medium of 462 sq.ft. Froth overflows on both sides of each cell unit. The tonnage of original flotation feed handled per square foot of porous medium is 2.49. The framework of the cell is steel. Pulp goes to these cells at 20 per cent solids. The amount of reagent used per ton of ore floated is as follows:

Reagent	Pounds per Ton Floated
Coal tar	0.91
Creosote	0.06
Pine oil	0.07
Total	1.04
Lime	1.51

These cells operate at an air pressure of 4½ lb. This air is produced by two No. 8 Root high-pressure blowers for the three units now operating, though four of these blowers are installed.

The concentrate produced by these cells is sent to cleaner cells by means of air lifts, excepting the concentrate produced by the first air bottom, which is sent with the concentrate from the cleaner cells. The cleaner cells are set up above the feed end of the roughing cells, one duplex unit to each duplex rougher unit. Each duplex unit contains six air bottoms, three in line. The air compartments are the same size as the rougher compartments. Three-play canvas blankets are used and give about ninety days' service. The cells are removing 33.7 per cent of the total mill concentrate by weight and 50 per cent of the total copper recovered, in a concentrate assaying 12.75 per cent copper.

The concentrate as produced is sent to two Plat-O tables, where the heavy iron content is removed and sent to the Blaisdell tanks, the remainder of the concentrate going to 75-ft. Door tank trays. The flotation tailing from the rougher cells is given a finishing treatment on eighteen Plat-O finishing tables, after which it is discarded as a finished tailing. These tables have the same driving mechanism as the roughing tables and are driven at a speed of 290 r.p.m. They are removing 4.4 per cent of the total mill concentrate recovered, by weight, and 2½ per cent of the total copper recovered, at a 4.95 per cent copper assay. The con-

centrate as produced is sent to the same Blaisdell excavator tanks as the primary roughing table concentrate.

The concentrate dewatering system consists of four 30-ft. Blaisdell excavator tanks, the overflow of which goes to one 30-ft. diameter Dorr thickener. The overflow of this Dorr thickener is pumped to one 75-ft. Dorr thickener. The Blaisdell tanks are 11 ft. deep inside, and each tank has a capacity of 600 dry tons of concentrate. The tanks are equipped with filter bottoms and are connected with a vacuum pump system for the final removal of water. The Blaisdell tanks are installed adjacent to the filter building on the down-hill side, and the concentrate from these tanks is excavated directly into railroad cars. For flotation concentrate, two 75-ft. Dorr tanks are employed. Each tank is equipped with one steel tray and two sets of rakes. The settling depth above the tray and above the tank is 8 ft. in each case.

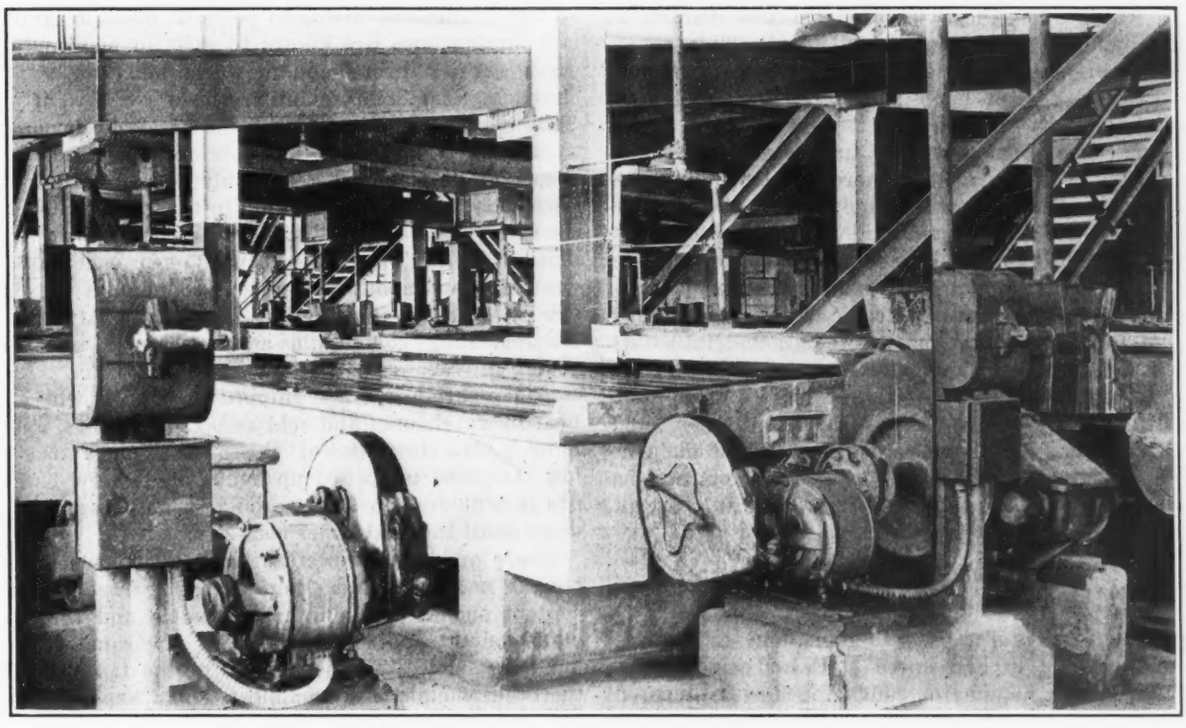


Table flow, showing concrete construction and individual motor drives using 1-hp. motors and gear reducers

The building which houses the vacuum filter equipment, including filters, compressors, vacuum pumps, and water pumps, is a three-story structure of steel and concrete. Five Oliver filters are installed on the top floor, but only three are in use. The filter drums have a diameter and face of 14 ft. and are driven by a 3-hp. motor. On account of the high location of the filters, it is necessary to elevate the spigot product from the Dorr tray tanks to these filters. To accomplish this two elevators, 65 ft. high, are used, one being a spare. Concentrate from the filters is discharged directly into railroad cars.

The following equipment is installed on the lower floor of the filter plant:

Two No. 6 Krogh turbine pumps direct-connected to 25-hp. motors. These pumps are used to return the water to the mill pump sump.

Two 16x12-in. Sullivan compressors, belt driven, 50-hp. motors. These compressors are making 30-lb. air, which is used for the air lifts that take the table concentrate to the Blaisdell tanks.

Two 20x14-in. Sullivan compressors, belt driven, 100-hp. motors. These compressors are making 15-lb. air, which is used for the air lifts that take the rougher flotation concentrate to the cleaner cells, and for blow-off air for the filters.

Three 17x10-in. Ingersoll-Rand vacuum pumps, belt driven, 50-hp. motors.

One 23x12-in. Ingersoll-Rand vacuum pump, belt driven, 100-hp. motor. These pumps furnish the vacuum for the Blaisdell tanks and also for the Oliver filters.

All recovered water from this department is pumped to a general mill sump. The sand concentrate averages 5 per cent water and the filter concentrate 14.9 per cent, the weighted average being 7.7 per cent.

For the recovery of water from the concentrator tailing one 200-ft. diameter Dorr thickener and three 75-ft. Dorr tray tanks are used. The 75-ft. tanks are the same type as those used for concentrate thickening and may be used for tailing or concentrate as conditions warrant. The 200-ft. tank has two long double rakes carried on a steel beam truss; these rakes cover the entire tank bottom and make one revolution in fifty-five minutes. Short rakes are installed around the center of the tank. The rake is driven by a 5-hp. monorail motor, which operates on a rail covering the periphery of the tank.

All water recovered from both this system and the concentrate system is sent to a pump sump. The water is returned to the concentrator for re-use by means of three 15x16-in. Aldrich triplex pumps operated by direct-connected 125-hp. motors.

Marketing Tantalum Ores and Metal

A Rare Mineral Product Whose Use Is Expanding

By David Taylor
The David Taylor Co., 30 Broad St., New York.

METALLURGISTS AND CHEMISTS, in this country and in Europe, for many years have been carrying on research work in an effort to find commercial, practical uses for tantalum in quantity. About 1900 there was put on the market an electric lamp having a tantalum filament. This apparently had great possibilities, in being far more efficient than the old carbon lamp and in having a filament strong enough to stand a fair amount of use. About the same time a lamp with a tungsten filament also appeared. It in turn was more efficient than the tantalum filament, from the standpoint of electric consumption and lighting quality, but the tungsten filament was so fragile that these lamps could not be used where they would be subjected to vibration or jarring. Tantalum lamps, therefore, appeared to be especially adapted for use in mills and in other industrial establishments using machinery, and for a while they were quite extensively used. Within a year or so after their appearance, however, the General Electric Co. perfected the Mazda lamp. This contained a tungsten filament strong enough to stand vibration and jarring, and as a result tantalum lamps were soon discarded, except in special sizes for special work.

Metallic Tantalum Production a Recent Commercial Development

Much experimental work was then done in the use of ferrotantalum in high-speed steel and kindred industries. So far no apparent advantages over tungsten have been found for this purpose, and as the tantalum is much more expensive than the tungsten this line of research has not developed beyond experiments.

In Germany tantalum metal produced by Siemens and Halske at Charlottenburg has been used in a small way in the manufacture of certain kinds of pen points and in dental instruments. The production of uniform, pure metal in large enough sheets or rods to give it an extended use in this field was not accomplished until about 1921, when Dr. Clarence W. Balke, in the laboratories of the Fansteel Products Co., developed a new process which is now in use, and under which a uniform and pure metal can be produced in any size sheet or rod required. Since that time a number of uses have been proposed for it, and its use is rapidly developing in the manufacture of dental instruments and dental spatulas, surgical tools, pen points, filament wire for incandescent lamps of thermionic tubes, plates and support wires for thermionic tubes, hypodermic needles, cathodes for use in electrochemical analysis, analytical weights, laboratory dishes, spatulas, stirrers and other devices in which a perfectly acid-proof metal would be more suitable than porcelain or glass; parts of scientific instruments, acid-proof pumps and parts of commercial chemical equipment, and electrolytic valves for the manufacture of rectifiers for obtaining direct current from alternating current course, as in battery chargers, electrolysis apparatus, radio, and similar uses.

The Fansteel Products Co., at North Chicago, is having good success in developing a market for tantalum articles, and although the actual amount of ore now used is small the prospects for increased requirements in the future are excellent. Probably, at present, the annual world's consumption is not over ten tons of ore, containing about 56 per cent metallic tantalum.

Tantalum ores are known to exist in many mineralized localities throughout the world, but have been produced in commercial quantities in only a few of them. This is probably because there has been no demand for any quantity and there has therefore been no inducement for development. The only deposits from which there has been any production in the United States are near Keystone, S. D. This ore is a columbite, and as shipped contains roughly about 35 per cent tantalum pentoxide and about 30 per cent columbium pentoxide. Ore containing the highest percentage of tantalum (disregarding columbium and associated metals) is found in very remote regions of Australia. A few tons of it are mined and shipped to London, where it is held in warehouses and sold as occasion offers, and the mine is then closed down. When the London stock runs low the mine is opened up again and a new batch of ore is sent over to London, and the mine again closed down until the next order comes in.

There are no set specifications on which the ore is bought and sold other than that the actual tantalum content should be as high as possible and the columbium content and other metals of the same group as low as possible. The separation of the tantalum from the other metals is a complicated and expensive process, and so far no commercial uses for the other metals of the group have been found. The Australian product is very much preferred, chiefly because the consumers know that "it works satisfactorily"; but up to the present little attention has been paid to ascertaining just what elements in the ore are detrimental or advantageous. This, however, will come in time as the demand increases, and maximum allowances of various impurities will probably develop, as they have in tungsten, vanadium, and other ores.

There has not been enough demand for analytical work to warrant dependable commercial laboratories developing satisfactory methods for analysis. For instance, Ledoux & Co., of New York, do not undertake the work, and refer any inquiries they receive to Dr. James, of the University of New Hampshire. The sellers naturally prefer English analysis: consumers in the United States, in the event that they cannot buy on their own analysis, prefer weighing, sampling, and analysis of imported lots by some recognized American firm. The result is very unsatisfactory. As an instance of this, my own company recently bought a lot of high-grade Australian tantalum in London. The consumers naturally did not like to pay out a large amount of money on the analysis of even the most reputable English chemists without an opportunity to check the results in this country. The sale was therefore made on the following basis: The British analysis, based on British sampling, is to be sent over to this country. The shipment is to be sampled and analyzed

at the consumer's plant. The analyses for tantalum are then to be compared, and settlement based on the average if they agree within 2 per cent Ta_2O_5. If they do not thus agree an umpire analysis is to be made by Dr. James. The question then arises: is the umpire analysis to be made on the pulp sample taken in England or on the pulp sample taken at the buyer's plant; and the result will probably have to be an analysis by Dr. James on each sample and his results of the two averaged.

The product is always handled through some broker or dealer, and so far as I know no sales are ever made direct to the refiners. As the demand increases direct contact between producers and consumers will probably be established, as has been done in the case of all other metals, but in the meantime the consumers are too busy with manufacturing details and use too small an amount to warrant their purchasing departments spending much time in correspondence with producers, many of whom have never actually produced any of the ore and do not therefore exactly know what quantity or grade of ore they can mine.

Tantalum of a purity of not less than 99.8 per cent is a steel-blue color when unpolished, and nearly a platinum white color when polished, the polishing probably removing the thin film of oxide which is on the unpolished metal. The melting point is 2,850 deg. C.; the specific gravity of the worked metal is 16.6. The tensile strength of the drawn wire may reach as high as 130,000 lb. per square inch. The linear coefficient of expansion is only slightly less than that of platinum and is more than molybdenum or tungsten. The electrical resistance is high, being about eight times that of copper and three times that of tungsten. Its chief objection is that it oxidizes when heated in the air, the surface becoming blue at about 400 deg. C. It combines with hydrogen or nitrogen at high temperatures and will absorb 750 times its own volume of hydrogen, forming a tantalum hydride, which is a coarse-grained brittle product. The pure tantalum is soft and ductile but becomes harder on absorption of gases.

A series of tests were made by the Fansteel Products Co., during which the sheets were immersed, either wholly, or partly exposed to the air, in the following reagents. They showed no gain or loss in weight at the end of fifty days: Concentrated sulphuric acid, dilute sulphuric acid, concentrated hydrochloric acid, dilute hydrochloric acid, aqua regia, glacial acetic acid, 10 per cent acetic, 50 per cent formic, 12 per cent formic, 10 per cent oxalic, 85 per cent phosphoric, 10 per cent phosphoric, 5 per cent carbolic, 15 per cent tannic, 20 per cent sodium acetate solution, 10 per cent iodine solution, citric acid solution, 10 per cent potassium hydroxide solution.

In a similar test, after immersion of tantalum sheet in 33 per cent potassium hydroxide for 120 days, the metal showed a discoloration but no change in weight. At ordinary temperatures the only chemical reagent so far examined which attacks the metal is hydrofluoric acid, but this action is very slow when both metal and acid are pure. A mixture of hydrofluoric and nitric acid will attack it rapidly, causing it to go into solution as tantalum fluoride.

The price of tantalum metal sheet is from $300 to $400 a kilo, depending on thickness and length of pieces.

Fluorspar Production Decreased in 1923

SHIPMENTS of fluorspar in 1923, according to a statement compiled by Hubert W. Davis, of the U. S. Geological Survey, showed a decrease of 16 per cent in quantity and 3 per cent in total value compared with 1922. The reported average selling price f.o.b. mine shipping point increased from $17.88 in 1922 to $20.69 in 1923. Colorado and New Mexico were the only states that showed an increase in 1923. The decrease in shipments in Illinois amounted to 23 per cent. The shipments of fluorspar to foundries and for use in the manufacture of hydrofluoric acid, glass, enamel, and sanitary ware were larger than in 1922, and the shipments to steel plants and for export were smaller. The stocks of fluorspar at mines or at shipping points at the end of 1923 amounted to about 64,000 short tons, compared with 33,337 tons at the end of 1922. These stocks are the largest ever accumulated by producers and may result in curtailment in output in 1924.

The imports of fluorspar into the United States in 1923 amounted to 42,226 short tons, the largest since 1910. The imports in 1923 were equivalent to 35 per cent of the domestic shipments of fluorspar, compared with 23 per cent in 1922. England was the principal source of the imports, supplying 54 per cent of the total. The importation from British South Africa of 10,380 short tons of fluorspar, practically all of "acid" grade, is noteworthy. Imports from Italy, China, and The Netherlands were recorded for the first time in 1923.

The producers of about 95 per cent of the basic open-hearth steel made reported that they consumed 130,499 short tons of fluorspar in 1923 and had stocks on hand amounting to 47,219 short tons on Jan. 1, 1924. If the steel companies that did not report consumed a like proportion of fluorspar, the figures given indicate a total consumption in all steel plants of about 137,000 tons in 1923 and total stocks of about 49,700 tons on hand Jan. 1, 1924. The total consumption of fluorspar by steel plants in 1922 was about 104,000 tons and the total stocks on Jan. 1, 1923, were about 65,000 tons. The consumption of fluorspar per ton of steel produced in 1923 averaged 8.1 lb.; in 1922, 7.4 lb.

The following figures for 1922 are final, but those for 1923 are subject to slight revision:

Fluorspar Shipped in 1922 and 1923, by States

State	1922 Short Tons	1922 Value Total	1922 Value Average	1923 Short Tons	1923 Value Total	1923 Value Average
Illinois	83,855	$1,493,188	$17.81	(a) 64,700	(a) $1,426,300	(a) $22.04
Kentucky	52,484	970,059	18.48	45,441	945,402	20.81
Colorado	2,309	20,169	8.73	(a) 5,000	(a) 49,000	(a) 9.80
New Mexico	2,180	30,992	14.22	(a) 3,800	(a) 40,800	(a) 10.74
New Hampshire } Utah	768	16,757	21.82	142 } 188	6,356	19.26
	141,596	$2,531,165	$17.88	(a) 119,271	(a) $2,67,858	(a) $20.69

(a) Approximate and subject to revision.

Fluorspar Shipped in 1922 and 1923, by Uses

Use	1922 (Final) Short Tons	1922 (Final) Value Total	1922 (Final) Value Average	1923 (Approximate) Short Tons	1923 (Approximate) Value Total	1923 (Approximate) Value Average
Steel	122,403	$1,987,586	$16.24	95,733	$1,751,465	$18.30
Foundry	2,998	57,011	19.02	3,206	71,318	22.25
Glass, enamel and sanitary ware	8,904	323,116	36.29	10,718	388,015	36.20
Hydrofluoric acid	4,782	118,648	24.81	6,631	193,406	29.17
Miscellaneous and unknown	213	3,838	18.02	1,839	38,342	20.85
Exported	2,296	40,966	17.84	1,144	25,312	22.13
	141,596	$2,531,165	$17.88	119,271	$2,467,858	$20.69

The Fate of Sulphur Combines

Artificial Control in Sicily Costly to Producers

By C. L. Breger

SULPHUR MINING is the main industry and backbone of Sicily, and the foremost mineral industry in Italy. Four ruinous failures of four different Sicilian sulphur trusts are a classic epic on the economic asininity of increasing prices by withholding production from the market. Of special interest are the four successive Sicilian sulphur trusts. The first two enjoyed a practical world monopoly of sulphur, yet went to smash. The last two failed, though backed by the Government of Italy, a special new bank, and the banks of issue, even to the extent of creating legal-tender money based on sulphur warrants—warehouse receipts. The first Consorzio Obbligatorio (1906) was later copied by the German Kali-Syndikat, or Potash Trust, (1910), and other Zwongs-Syndikaten and Sozialisierungs developed by Rathenau 1915-1921, and the U. S. Railroad Administration under McAdoo.

The first Sicilian sulphur monopoly was engineered in 1838 by M. M. Taix et Cie., of Marseilles. They took all the output, then 90 per cent of entire world production. They raised prices from $25 to $75 a ton. Next year iron pyrite started to compete with high-cost sulphur, to make sulphuric acid. The pyrite industry, then and thus developed, lasts to this day as sulphur's competitor. The French pool collapsed. The price fell again to $25; then to $10 and less. Investments baited by high prices in 1838-39 were ruined, and Sicily was under a pall for decades.

The *Societa Anglo-Siciliana* was the second trust, nearly fifty years later. The worldwide hard times in the early 90's hit Italy. Sulphur was down to $10 to $11 a ton. The new combine daringly offered to pay a fixed price $14.20 (raised to $15.80 next year when the $1.93 export tax was rebated) for five years to Aug. 1, 1901, and signed contracts with 80 per cent of production, and also bought the Chance-Claus patents for byproduct sulphur.

The Anglo-Siciliana lifted the price to $18 in a few days, and held it there, stabilized, for years, and paid good dividends.

In reality the trust was holding the bag. It bought 267,795 tons and sold only 156,017 tons the first year. Ruin was staved off by the worldwide boom of 1898-1901, which caused it, when 1901 came round, to renew its contracts for another five years.

Then disaster. Uncontrollable output by outsiders, which no pool can negate, swelled Sicilian output to 536,782 tons in 1905, a figure never reached before, nor since. Serious Louisiana competition also started in 1903-5. The Anglo-Siciliana went to the wall in 1906 in the midst of a world boom! Its 360,000 tons of stocks, in which it had invested over $5,000,000 cash, were taken off its hands at near $2,000,000, less than original cost price.

The Italian Law No. 333 of July 15, 1906, then forced all the Sicilian sulphur mines into the compulsory trust, or Consorzio Obbligatorio, which received a sole monopoly of selling, pledging, shipping, and moving sulphur, with czaristic power to curtail production and fix prices. Besides other aid, the government and the Bank of Sicily founded a special mines bank to help. The law also authorized the Banco di Sicilia to discount and rediscount notes secured by sulphur warrants, or warehouse receipts, and to issue notes on that security.

In practice the mine delivered its sulphur to the Consorzio, and was paid a "provisional price" per ton, payment being in Consorzio "warrants." The mine immediately cashed or discounted the warrants at the bank, and after the fiscal year received the final balance or selling price, over and above the provisional price. The Consorzio took over the 360,000 tons stocks of the Anglo-Siciliana, to market them gradually over twelve years. In 1907 the Luzzatti-Frasch accord bound Italy not to sell in the United States, and our Union Sulphur Co. to keep out of Italy's Mediterranean markets.

The Consorzio was a failure. The stocks of 360,000 tons, instead of being worked off, had grown to 640,000 tons.

The state came to the rescue in 1910. The government donated more capital to the mines bank. It further authorized the mines bank to raise more funds by selling collateral-trust bonds, secured by sulphur warrants. The law also authorized all three banks of issue of Italy, not merely Sicily alone, to discount and rediscount notes secured by sulphur warrants, and at 1 per cent under the legal charge.

Two American companies, the Freeport Texas and Texas Gulf, started production in the war. They were unbound by the Luzzatti-Frasch accord of 1907 to keep out of Italy's market. When in late 1920 the prohibitive ocean freight, that had been $18 to $20 a ton was reduced to $5, Texas sulphur could be laid down in Sicily cheaper than Sicily's own mines could produce it. Sicilian sales vanished in 1921-22.

Then party politics weirdly intruded. The Italian elections of 1921 were on. The government party (the Consorzio head was its appointee) refused to lower posted prices for sulphur, and "pointed with pride" to high prices and high wages. Meanwhile Sicily sold no sulphur. Banks were advancing huge sums on warrants fictitiously valued. Huge wage bills were being paid out for sulphur for which no *bona fide* market existed. Over 273,000 tons of extremely high-cost sulphur piled up in the Consorzio warehouses by April, 1922. It was hypothecated to the banks which had loaned 83,000,000 lire. The Consorzio also owed its members and others about 40,000,000 lire more. The Consorzio was *sans* funds, *sans* collateral, *sans* credit. The mines petitioned to have the Consorzio dissolved, and that they be permitted to produce and sell their own sulphur—such as could. The Bank of Sicily refused longer to discount notes secured by sulphur warrants. The great savings banks of Palermo were deeply immersed on sulphur advances. The Mussolini revolution turned out the old Consorzio political direction, continued the Consorzio as a "formula," installed a Sulphur Dictator, and after nearly a year, negotiated the accord of March, 1923, with the American producers.

The new accord binds Italy to limit total Sicilian exports, to keep the 273,000 tons stocks off the market, to be sold gradually in eight or nine years by the Consorzio. The Government of Italy guarantees Consorzio bonds, which the banks will receive for turning title to that sulphur back to the Consorzio. Within a few years the banks may come out with whole skins. The mines have, of course, been ruined—small mines as well as big mines. The fittest might have survived in the free struggle for existence, but artificial management, pooling and handicapping the strong to make them carry the weak, permanently, even under most favorable circumstances, as in Italy, kills in the end the fit and the unfit together.

Technical Developments in Copper Smelting

A Commentary on What Is Going On at Some of the Southwestern and Tennessee Plants

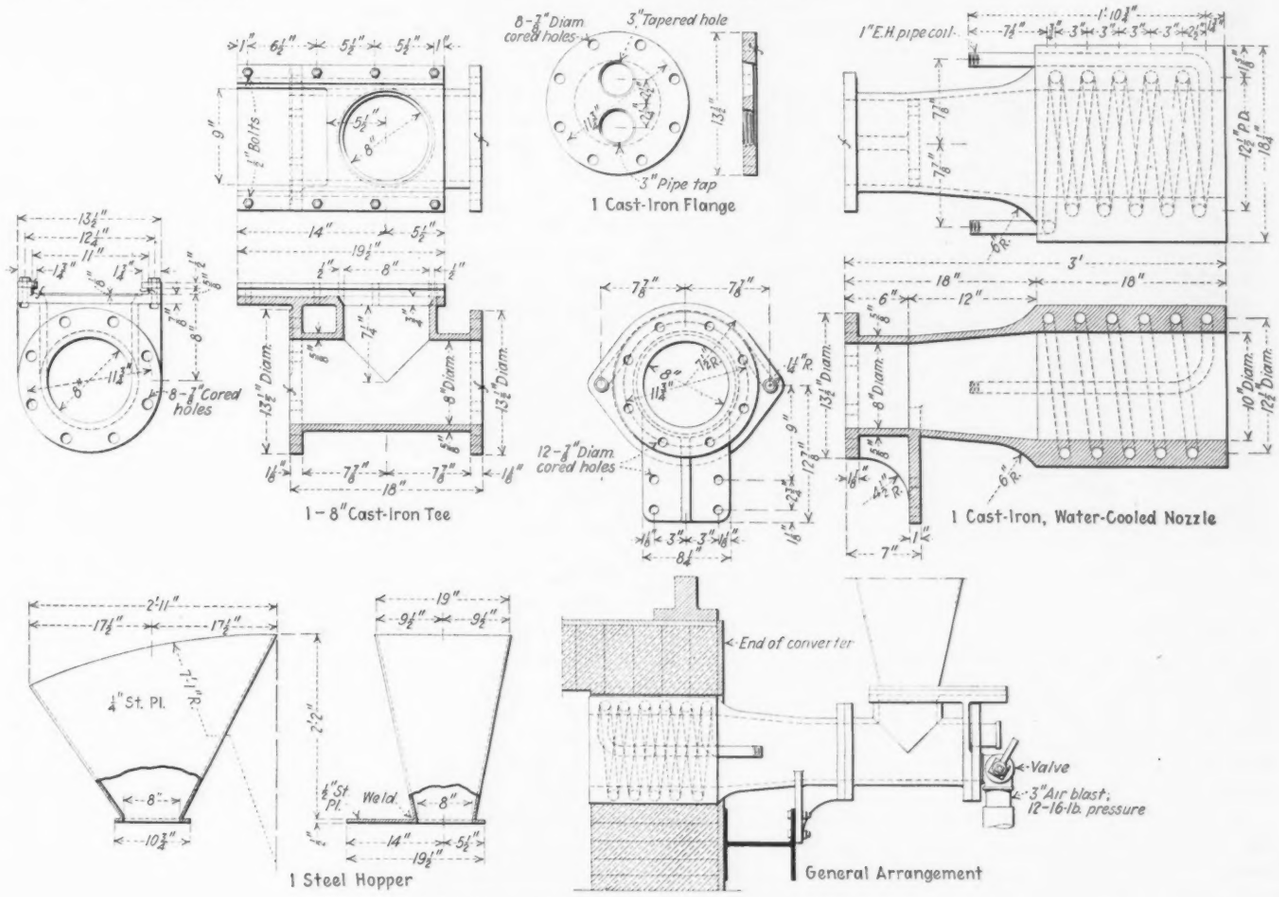
By Edward H. Robie
Assistant Editor

ALTHOUGH practice in copper smelting has not changed radically in recent years, notable progress has been made in improving details to attain better recovery and lower operating costs. About ten or fifteen years ago, basic converting was introduced, and that method has been adopted by practically every smelter of any size. Following that by a few years, the large reverberatory furnaces, from 18 to 25 ft. wide and 90 to 120 ft. long, underwent a marked development, chiefly in the method of firing and feeding.

Blast furnaces are still in use at most smelters for coarse material and where semi-pyritic smelting can be carried on, but the proportion of ore adapted to blast-furnace smelting is constantly decreasing. Low-grade ores must be concentrated, and the fine concentrates can be treated much more efficiently in the modern reverberatory.

In this article, brief mention and comment will be made of the practice at some of the representative copper smelters of the American continent. These notes are largely the result of a recent trip made into Tennessee and the Southwest, and written communications and talks with the superintendents of some plants which it was not possible to visit. No attempt at complete plant descriptions will be made.

The El Paso Smelting Works, of which H. F. Easter is superintendent, situated two miles or so up the Rio Grande from the main part of the city of El Paso, Tex., is of interest both to copper and lead metallurgists, as it is one of the few smelters where ores of both metals are treated. No great amount of activity in either branch was in evidence when I was there last fall: of the eight lead blast furnaces, three were in use, largely on the ores from Ahumada and Erupcion; in the copper department, three of the eight Wedge roasting furnaces were in operation, one of the three reverberatories, one of the two 13x30-ft. Peirce-Smith converters, and one of the two anode furnaces. The one Great Falls type converter was not being used.



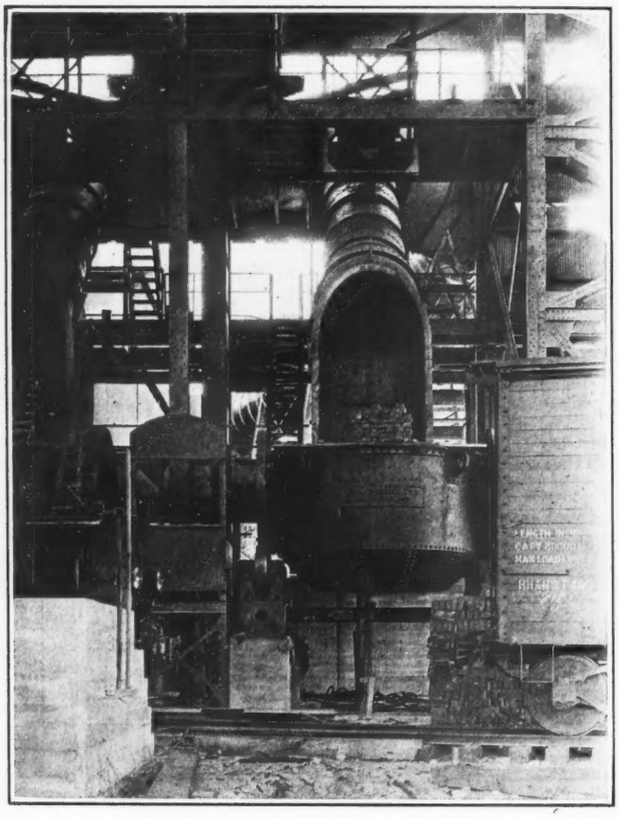
Constructional details of the Garr Gun

Patented in the United States and principal foreign countries.

The Chino concentrates now form the principal supply of copper-bearing material at the El Paso smelter. Some matte from the lead department is also sent to the copper converters, the transfer being made when the copper builds up so that there are four parts of copper to one part of lead.

Two of the El Paso reverberatories are 25 ft. wide and the other is 21 ft. in width. These furnaces have the matte tap-holes about halfway along the side, the slag being skimmed off at the front under the flue. (Why is the flue end of a reverberatory called the front, and the firing end the back?) The matte runs about 45 per cent copper; this is more the result of high-grade concentrates than of prolonged roasting, for the sulphur is reduced only 3 or 4 per cent in passing through the Wedge furnaces.

An effort is made to keep the copper in the slag at not over 0.4 per cent. This was one of the first smelters to use the Garr Gun for blowing flux into the end of a horizontal converter, and as there is an occasional inquiry for the details of this device, the drawings are reproduced herewith. They may at least be



Converters under construction at the Magma smelter

of interest to foreign readers, and they have never been published so far as I know. The inventor was S. R. Garr, one-time foreman of the copper converting department at the Garfield Smelting Works, and the patent, No. 1,209,282, is controlled by the American Smelting & Refining Co., to which I am indebted for the sketches.

The operation of the device is exceedingly simple, the crushed flux merely being dropped in a steady stream into the hopper, whereupon it is blown into the converter with air at the same pressure as that used for the converter. A bin is usually provided above the device to hold the proper amount of flux for one blow, which is then gradually emptied into the Garr Gun by manipulating a gate at the bottom of the bin.

At Globe, Ariz., there is little change in the Old Dominion smelter. No provision has ever been made for smelting fine ore, concentrate or flue dust, this class of material going to the International smelter at Miami. Only one of the three blast furnaces was in operation last fall, and the converter was therefore used only intermittently. Not long ago, the balloon flue leading from the converters became so badly corroded as to threaten to fall to pieces, but it was repaired at about two-thirds the cost of a new flue, as follows: A skeleton of $\frac{3}{8}$-in. rods was laid over the old shell, spaced in squares about $1\frac{1}{2}$ in. apart. This formed the support of $1\frac{1}{2}$ in. of gunite (sprayed cement). The flue now seems as good as ever, if not better. It is probable that calcium sulphate has been formed on the inner surface of the gunite, this compound being resistant to the acid gases.

The neighboring International smelter at Miami has not changed its practice to any great extent in the last few years, and is the same immaculate plant as ever. The reverberatory slags are run higher in silica than formerly, an average analysis of the slag from the solid charge being 51 per cent silica and 17 per cent alumina. However, all of the converter slag is poured into the reverberatories, so this brings the silica content of the total mixed slag to a somewhat lower figure. A new Peirce-Smith converter, 10x20 ft., using the Garr Gun, has recently been installed. L. O. Howard, the superintendent of the smelter, finds this type of converter an improvement on the Great Falls model formerly used exclusively. The grade of the concentrates smelted is a little lower than formerly, so that the matte going to the converters now runs about 35 per cent copper.

The new smelter of the Magma Copper Co. at Superior was under construction when I was there, as shown in the accompanying photograph, which, however, gives a good idea of the plant layout. It went into operation at the end of March. Concentrates are pumped from the mill to the Oliver filter plant at the smelter. Concrete receiving bins are provided for the dewatered concentrate and other materials, a complete belt conveyor system being installed for transporting the material to and from the bins. The concrete bedding bins have a capacity to supply the smelter for about twenty-five days. Roasting is done in five eight-hearth Herreshoff furnaces, connected with a Cottrell plant, the gases finally being discharged through a 300-ft. brick stack, 26 ft. in diameter inside at the base and 20 ft. at the top. The brick for this stack and for the other smelter construction was made in the company's own brick plant.

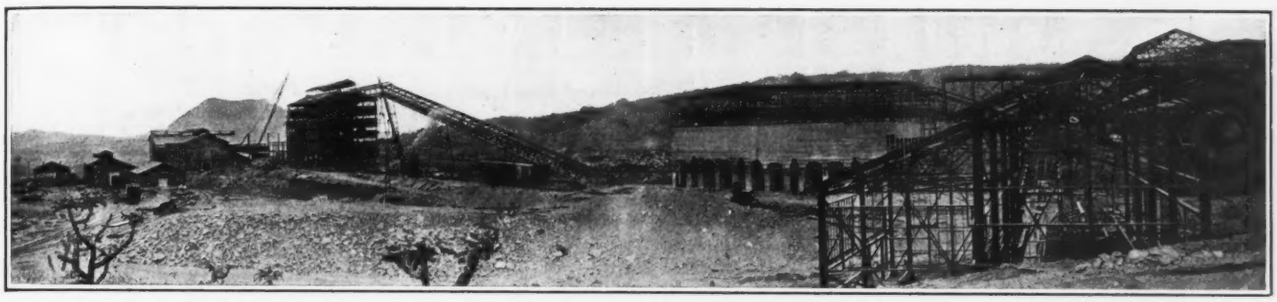
One reverberatory is provided, 100 ft. long by 22 ft. wide, inside. The matte will be converted in an Allis-Chalmers upright converter, two of which are provided, and one of which is shown in an accompanying photograph. Two Erie City 700-hp. waste-heat boilers utilize the gases from the reverberatory, and these may be fired direct with oil burners if additional steam is required. Power is generated by two Westinghouse steam-turbine electric generators of 1,500 kw. each. A Nordberg compressor with a capacity of 12,000 cu.ft. per minute compresses air for the converters.

The capacity of the new smelter is from 3,000,000 to 4,000,000 lb. of copper per month, depending upon the grade of the material charged. In 1923, the small amount of direct-smelting ore carried about 15 per cent of copper, and the concentrates, 10 per cent. A more complete description of the plant, with some account of the results secured, will be published soon.

Formerly the Magma concentrates were smelted at the American Smelting & Refining Co.'s plant at Hay-

den. Now that these no longer go there, and with the Ray Hercules mine closed down, the Hayden smelter depends almost entirely on concentrates from the Ray Consolidated. About the only new thing of importance at this plant is a Cottrell system for recovering the dust from the roaster gases. A screen Cottrell system was installed which cost only about $90,000, compared with about $150,000 for the regular method of Cottrell precipitating for a plant of this size, and seems just as satisfactory.

At Cananea, a new bedding system has recently been installed, but aside from that no new important changes in equipment have been made. Roasting is done in 16-ft. inside diameter six-hearth McDougalls and two 21-ft. Wedges with seven roasting hearths and one drier hearth. The rabble arms in the smaller furnaces make one revolution in about thirty-eight seconds, and in the Wedges, one revolution in fifty-five seconds. At El Paso about the same speed was noted—fifty-seven seconds. The 16-ft. furnaces roast about 75 tons per



Filtration plant, bins, roaster building, power house and smelter at the Magma Copper Co., Superior, Ariz., as they appeared when under construction, Nov. 7, 1923

Two large reverberatories were running at Hayden last fall, one 13x30-ft. Peirce-Smith converter, with one of the Great Falls type held in reserve.

Some years ago a complete system of powdered-coal firing was installed for the reverberatories, but this has now been abandoned and oil firing is used exclusively. Owing to the high-ash Gallup coal, abrasion was very bad and the distribution was not satisfactory.

An artificially made magnetite coating is used to preserve the magnesite brick with which the shell is lined. The method of making and applying this magnetite coating has been improved in several respects since the practice was first introduced, about ten years ago. At Hayden, low-grade matte is put in a converter and blown without flux for two hours or so. The magnetite slag thus produced is then poured off and transferred to the tuyère line of a converter in which the brick lining has been badly attacked so that it is in need of repair. This will then last for about a month before the operation must be repeated.

Formerly, a good deal of trouble was experienced from the formation of magnetite in the reverberatory furnaces. This, it is thought, was due largely to the presence of magnetite in the converter slag, which is poured into the reverberatories for cleaning. The trouble has been obviated to a material extent by keeping the converter slag fairly high in silica—about 20 per cent. Formerly it was as low as 12 per cent sometimes. About the only way to get rid of the magnetite in the reverberatory, once it has formed, is to run the furnace very hot and keep the grade of the matte low, but it is a slow job.

Slag is removed from the Hayden reverberatories through a cast-steel tapping block, this smelter being a pioneer in this practice, I believe. At some plants they still open up the whole bay and rabble around. The slag is tapped three or four inches below its surface and the crust is allowed to remain in the furnace to be gradually smelted away. There has been no trouble in doing this, with either oil or coal-dust firing. When coal was used, however, it cost a good deal to keep the flues clean of ash.

day and the 21-ft. furnaces about 100 tons. Costs are around 45c. per ton.

Two 19x100-ft. reverberatory furnaces were in operation at the time of my visit. Tampico fuel oil, costing a little less than $2 a barrel, was used for fuel, along with 34-oz. air. About 300 barrels of oil is used per furnace per day to smelt from 475 to 500 tons of solid charge. The oil burners are arranged as shown in the illustration. Draft in the flue is maintained at from 0.10 to 0.12 in. of water, being automatically controlled, as at Anaconda, by one of the Wraith-Jones devices.

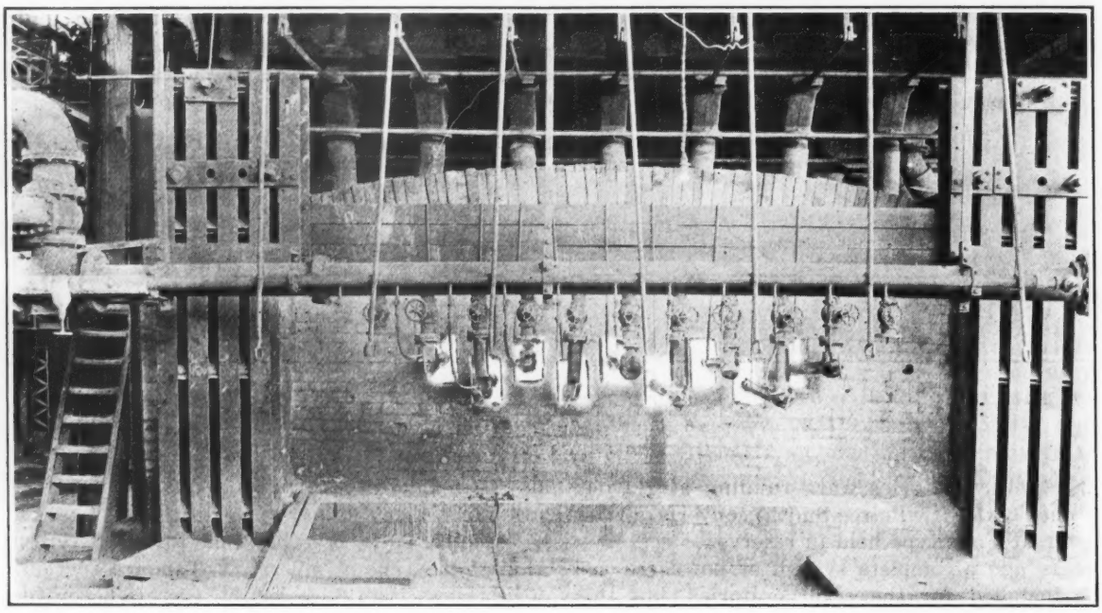
The draft in most reverberatories is watched; at El Paso for instance, a Hays differential draft gage is installed for the purpose, but automatic control is not so usual. The temperature in the flues leading from the waste-heat boilers at Cananea is from 650 to 675 deg. F.

The furnaces are charged through the roof along the side walls for a distance of about one-half the length of the furnace. Frequent charges of calcine and green ore are made—about every ten minutes—but the charge is not banked way up to the roof as is the usual practice. Rarely is it allowed to pile up more than half the height of the side wall above the surface of the bath. This is said to make for much more satisfactory smelting, chiefly by allowing more space for combustion. At this plant, the converter slag is charged cold instead of following the usual custom of pouring it in in the molten condition.

Portions of the roof and skewbacks have to be renewed every six or eight months. The side walls above the level of the charge must also be replaced occasionally, this repair being made while the furnace is running. Slag is skimmed through a clay hole, the slag outlet being broken out above the surface of the slag, in contradistinction to Hayden practice. The matte is tapped about twenty feet from the front of the furnace.

At Cananea, there are also eight blast furnaces, four of which were running last fall. Reverberatory smelting is much cheaper, being about $1.20 per ton, compared with $2.65 for the blast furnaces. One reason

for this is that coke costs $16 per ton; another that the reverberatory is credited with the steam produced from the waste heat, steam that would otherwise have to be generated in direct-fired boilers. The Cananea reverberatories are given a steam credit of from 50 to 51 per cent of the cost of the oil which they use for fuel.



Oil burners and construction of the furnace back of one of the Cananea reverberatories

At the Calumet & Arizona smelter at Douglas, blast furnaces are no longer used at all. Improvements made in the reverberatory practice at this and other plants have increased the capacity and decreased the fuel ratio of the C. & A. reverberatories to such an extent that, despite the higher cost of labor and supplies, costs are now about what they were in 1914, or about $1.25 per ton. This is allowing a steam credit of 40 to 42 per cent of the cost of the oil used.

In the opinion of H. A. Clark, the superintendent of the C. & A. smelter, the ideal reverberatory furnace would be about 25x110 ft., and he thinks that the method of charging is the weakest point of the present practice. Repairs no longer necessitate shutting down a furnace completely, as they formerly did. The roof section needing repair is merely caved, and the rest of the furnace partitioned off with sheet iron. Water is then used to cool that part of the furnace over which the new brickwork is to be built, and with little delay charging can again be started over the entire furnace.

Some years ago common red brick and concrete were used to some extent for the hearths of roasting furnaces, but this practice has now been abandoned by most operators in favor of firebrick. Mr. Clark thinks, however, a hearth of the proper kind of cast iron might be devised. The high-temperature cements, such as hytempite and thermolith, have proved excellent for cementing the brickwork, particularly around the shaft of the roasters, at this and other plants.

At the Copper Queen smelter, the Ambler system of mechanically introducing the feed to a reverberatory through a screw operating through the side-walls has occasioned considerable interest. This was described, in its early form, in the *Engineering and Mining Journal* of Jan. 29, 1921. To Dr. J. Moore Samuel, head of the Investigation Department at the Copper Queen smelter, I am indebted for the following statement as to the objects sought:

1. *Continuity of operation.* The present method of charging reverberatory furnaces—namely the introduction of quantities of comparatively cold material at one time—results in immediate lowering of the temperature of the furnace. Smelting rate varies from a minimum just after charging to a maximum just before charging. With the charge introduced at the average smelting rate, temperature conditions will be uniform at all times and a better fuel economy will result.

2. *Furnace depreciation.* Deterioration of side walls and reverberatory arch is due to the fluxing of the silica brick by dust particles from the charge. The present method of charging, dropping quantities of fine material a distance of three or four feet through the roof, results in releasing clouds of dust which assist in fluxing and hence destroying the silica brickwork. The continuous side feed makes practically no dust in the furnace.

3. *Furnace crucible.* The present tendency in the Southwest, due to advances in flotation concentration, is toward the smelting of a charge that is getting finer and finer. Such a charge, fed in the old way, has a very low angle of repose; it flows out in the furnace and does not cover the side walls. The results are that the side walls are unprotected and hence deteriorate, and slag losses are increased by the introduction of solid unfused charge into what should be the liquid bath. With the continuous side feed, charging the same material, the angle of repose of the material is steep enough to give a bank, which protects the side wall and gives a clear crucible which is not contaminated with unfused material. We expect that this will reduce slag losses, but cannot determine the amount of the reduction until this system has been tried out on one complete furnace.

It is too early yet to say whether the method of charging which is being experimented with at Copper Queen will be successful. It is understood that the early difficulties have included excessive wear on the screws; binding; smelting of the screws; and undercutting and boiling up of the charge in the furnace.

Smelting practice in Tennessee is different from that of the Southwest. Here the blast furnace reigns supreme, for two main reasons: principally, the ore that has been mined is of sufficiently high grade to make direct smelting advisable without fine grinding and concentrating; and, secondly, owing to the composition of the ore, semi-pyritic smelting with but little coke is possible. Furthermore, and as a consequence of the last factor, the gases are used for the manufacture of sulphuric acid.

At the Tennessee Copper Co.'s smelter at Copperhill there are two blast furnaces 32 ft. long by 56 in. wide at the tuyères, and one furnace 22½ ft. by 56 in. The following metallurgical data may be of interest:

Height of ore column, ft.	12
Blast pressure, oz.	50
Percentage coke on charge	4
Daily capacity of large furnaces when running right, tons	900
Assay of ore, per cent copper	1.6
Assay of ore, per cent sulphur	27
Assay of charge, per cent sulphur	22
Assay of quartz used for flux, per cent silica	98
Blast-furnace matte, per cent copper	15
Blast-furnace slag, per cent copper	0.32
Blast-furnace slag, per cent silica	37
Blast-furnace slag, per cent iron	38
Converter slag, per cent silica	24
Converter slag, per cent iron	56

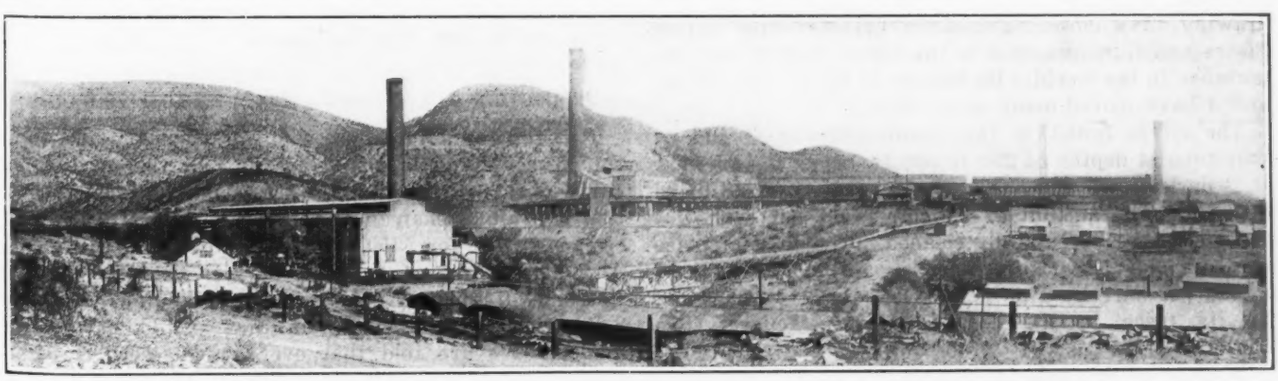
Part of the Tennessee ore is now concentrated, so it has recently been necessary to smelt from thirty-five to sixty-five tons of flotation concentrate a day. The tonnage was not sufficient to warrant the construction of a reverberatory, nor were there any custom smelters in the vicinity. The problem was similar to the one that the Granby metallurgists at Anyox, B. C., have recently faced. At the Anyox plant, several concentrating methods were considered: (1) Mixing the concentrate with flue dust and sintering with the Dwight-Lloyd; (2) blowing the concentrate through the blast-furnace or converter tuyères; (3) dumping the concentrate directly into the mouth of the converter; and (4) mixing the concentrate with coal and making coke from the mixture in the regular byproduct coke ovens. Perhaps when Mr. Munroe, Mr. Clapp, or Mr. Haffner read this they will write and tell us which method has finally been adopted and how it works. At Copperhill, as I mentioned briefly in the Annual Review number of the *Mining Journal-Press*, the concentrate is dried in a Lowden drier, mixed with the regular converter flux, and blown into the Peirce-Smith converter with a Garr Gun. If blown in without drying, there is a tendency to block up the end of the converter, and even when charged dry (that is with 8 or 9 per cent moisture, as is the practice), the end tuyères must be carefully punched. But the concentrate can be blown against weak places in the back of the lining and thus it helps considerably in extending the life of the costly magnesite brick. One might think that the loss in blowing fine high-grade material into a converter above the bath might be large, but the experience at Copperhill indicates that at least 95 per cent of the copper entering the process in that way is recovered. The concentrate contains only 15 per cent of copper.

The low-grade matte made by the furnaces also is only about 15 per cent, and therefore, of course, decidedly corrosive. The sole plates of the furnaces are water-jacketed and water is kept running against the outer shell of the settlers. These are large oblong vessels, lined with chrome brick, from which the slag overflows through covered skimming launders, after which it is granulated. There are four tapholes to each settler, water-cooled cast-iron tapping blocks being provided. All of the converter slag is poured into the furnace settlers, a practice which is also followed, in part at least, at Anyox and at Copper Cliff, Ontario. At the new British America smelter at Nickelton, Ontario, however, they are casting the converter slag in a casting machine and charging it to the furnaces cold.

When I was at Copperhill the furnaces were loafing along on 30 oz. of air instead of 50 oz., though at no particular sacrifice of fuel efficiency. As has been the experience elsewhere, pyritic smelting cannot be accomplished with flux that is poor in silica, and the 98 per cent silica content of the quartz is a necessity for proper running. At present, some of the copper produced at this plant is being granulated for the manufacture of copper sulphate.

At the neighboring smelter of the Ducktown Sulphur, Copper & Iron Co. there are two furnaces, only one of which was in operation at the time of my visit. The matte is treated in one converter, of the Great Falls type. The furnaces at Ducktown are different from those ordinarily used, but have been installed for a long time. The tops are flat, with side flues for the gases, and, of course, special provision for charging. The ore is not so good as at the Tennessee smelter, and 8 per cent of coke is necessary for smelting. The blast-furnace slag is granulated. The converter slag is poured over a bed of dampened flue dust, the mixture boiling up and then solidifying, making a suitable solid material for charging cold to the furnaces, after being recovered from the beds.

My thanks are offered for the courtesy and unvarying hospitality extended by the management of all the smelters visited; in every instance the freest inspection and consultation was allowed.



American Smelting & Refining Co.'s smelter at Hayden, Ariz. To the left is the power house

The Critical Line of Drilling in Oil-field Development

A Discussion of the Evil of Overdrilling, With Reference to the Petrolia-Oil Springs District in Ontario

By S. H. Brockunier
Mining Engineer, Lowell, Mass.

THE SITUATION that has existed in the petroleum industry for the last eighteen months is due to the neglect of economic laws that should be known to every operator. The very nature of the business, however, often makes it difficult to obey these laws or to predict the future. Anything that will assist the operator to stabilize the industry will be for the benefit of business in general. With this view in mind the present paper has been prepared.

Most oil fields, largely because of competitive developments, are overdrilled, and the overdrilling is not confined to small companies. It has been the overdrilling by large and small operators that has been keeping the price of oil below a comfortable margin of profit in recent months.

In each field, or on each lease, a point is reached where the new wells fail to sustain the production. This I have called The Critical Point, and the line of drilling, from the origin to this point, The Critical Line of Drilling. When drilling is continued above this line, the operation is likely to lose money on the development; when the drilling falls below it, the production will not be sustained.

Much can be learned from the Petrolia and Oil Springs oil field in Lambton County, Ontario, Canada, in this respect. While searching dominion and provincial government reports and private publications, I uncovered a mass of information in regard to this field. Many interesting facts came to light which have not heretofore been assembled under one heading. Such of these as seemed of general interest have been selected, and from them I have prepared curves showing the complete history of the pool in a graphical manner. These charts illustrate a method of studying oil development by the use of graphs, in order to control production and prevent the overdrilling that is so universally prevalent. In this instance the charts show that economies of development might have been introduced, which would have conserved the production to a later date and thus have secured a better market.

Lambton Field Productive Since 1862

The opening of the Petrolia-Oil Springs field began in 1860. A steady producer ever since, its life is now drawing to a close. Excepting fields of the United States and Rumania, this is the oldest field of any importance in the world. Its history is the history of oil, and it has outlived many newer fields.

The oil is found in the Corniferous or Onondaga limestone at depths of 250 to 500 ft. below the surface. It is dark brown and has a specific gravity of 28 to 36 deg. Bé. The amount of sulphur is 1½ per cent, but the oil can be successfully cleaned. The present price is $1.90 plus 52½c. government bounty, or a total of $2.42½ per barrel. This is 68c. less than is warranted by its place in the commodity price curve (See Fig. 1).

Writing of this field in 1873, Henry says:

"Though western Pennsylvania has produced many flowing wells of wonderful capacity, there is no quarter of the world where production attained such prodigious dimensions as in 1862 on Black Creek."

J. H. Fairbank, testifying before the Royal Commission in Toronto in 1890, says:

"The first drilling was done at Oil Springs in 1861. After a few wells had been put down, they struck the great flowing region. In the winter of 1861-1862 flowing wells produced largely, some reaching into the thousands of barrels in twenty-four hours. The great bulk of the oil went into the creek and was lost."

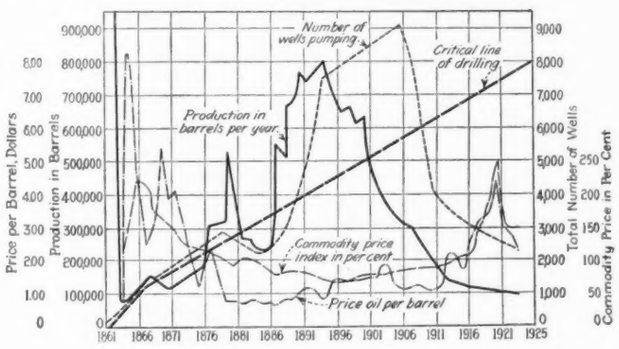


Fig. 1—Chart giving production of Lambton oil field, Oil Springs and Petrolia, Ontario, Canada

Dr. Alexander Winchell, a very careful and conservative scientist and geologist, in his "Sketches of Creation." Philadelphia, 1872, says:

"From detailed determinations I have ascertained that, during the summer of 1862, no less than 5,000,000 bbl. of oil floated off on the waters of Black Creek."

He lists thirty-three wells with production of 100 to 7,500 bbl. per day, altogether totaling 52,000 bbl. per day. In 1888 there were 3,500 wells pumping and 400 wells were being drilled per year. In 1898, 6,600 wells gave a monthly production of 57,000 bbl.

Corkhill (B. M., 1905) says:

"There have been in Lambton County about 11,000 producing wells, some of which have yielded oil for over forty years. At present (1905) there are 8,100 in operation at Petrolia and 1,000 at Oil Springs."

Clapp says:

"In the Petrolia field the plan was to drill one to ten wells to an acre."

Production Curve Shows Evil of Close Drilling

It is the opinion of those who worked in the field that the close drilling is an advantage, but the production curve does not substantiate this, and, in fact, proves that it is an expensive way to operate, even when a well can be drilled for $350, which is the case in that pool. The critical line of drilling was far exceeded in the Petrolia-Oil Springs field. The critical line points to 8,000 wells as the maximum that should have been drilled. We are told that over 11,000 were actually drilled, and the records show that of these 9,000 were pumping in 1906.

This field produced and saved 20,425,000 bbl. of oil, for which was received $32,792,000. This has been estimated by barrels per year and price per year. Redwood gives the capital invested here as $17,000,000 to $23,000,000. Clapp gives it as $2,750,000 in 1886, when the number of wells was 2,700. The latter figure seems more nearly right at that time. Using Clapp's figures as a basis for 11,000 wells, and including the probable land valuation, we get $11,500,000 as total capital invested to date.

Unified Control More Efficient

Had this whole field been under the control of one executive or one board of directors, the number of producing wells could have been reduced to 8,000, which would have decreased the capital invested by $2,500,000. If a single executive had platted working curves and analyzed the commodity-price curve and price-of-oil curve, he might have had sufficient vision to have regulated his drilling and production curves, so as to have produced the oil when needed most, and thus have secured the benefit of better prices. He might have even realized the ideal production curve shown in Fig. 2, and thereby have received $47,713,700 for the same amount of oil that was sold for $32,972,000. In that case his investment would not have been more than $9,000,000, instead of $11,500,000, and he would have secured an increased profit of $14,741,700. By properly financing

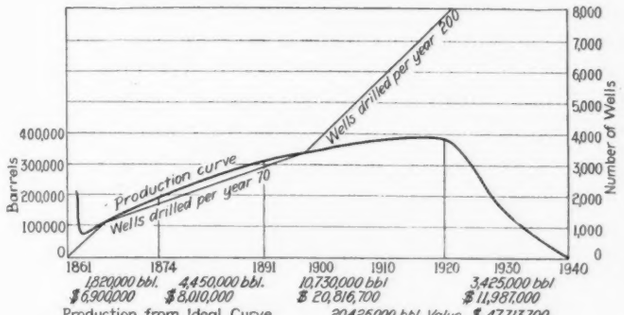


Fig. 2—Ideal curve, showing how production of Lambton oil field might have been conserved, with increase of value

this proposition over the period of time shown in Fig. 2 he could have built up a fine net profit and surplus. This is an ideal case, of course, but it shows the possibilities of an actual field with perfect co-ordination of the work.

It is hoped that no one will take exception to this presentation on the ground that it is a criticism of men or methods in this field. Such is not the intention. Since complete records of a field are seldom obtainable, these under discussion must be considered very valuable. Moreover, they lend themselves admirably to the illustration of a method whereby we may scan the future with the aid of records of the past and present.

Of course, we have improved production methods since this field was brought in. An executive of today would drill considerably fewer than 8,000 wells. He would install compressed air or similar pumping process, thus recovering even more oil, and he would do it at a less cost, despite the very low costs obtained in this field.

Disregarding the first wasteful year, nothing but praise can be said for the work as done under the then existing conditions and circumstances. My suggestion is that, from a modern standpoint, the field was very much overdrilled and that the peak production was obtained during a time of depressed prices, instead of being held back to stabilize the industry and to secure better prices.

The idea seems to have prevailed that, because of low prices, the production must be boosted to secure volume of business. A study of the graphs would have shown the fallacy of such reasoning. It would be difficult to get a more interesting example of how properly constructed graphs and curves can reflect all phases of the business, and give valuable aid in the direction of its affairs.

On the production chart in Fig. 1 the curves platted show production, number of wells pumping, the critical line of drilling, the price of oil per barrel, and the wholesale commodity index price taken from the Russell Sage Foundation.

The proper numeral for the intersection of a date and a particular curve can be read in its proper column to right or left of chart. Thus the intersection of 1886 with the production curve gives 240,000 bbl. in the second left-hand column. The intersection of 1891 with the price of oil curve gives $1.20 per barrel in the first column to the left. The intersection of 1891 with the wells-pumping curve gives, projected across to the first column on the right, 5,100 wells pumping. The intersection of 1921 with the commodity-price curve projected over to the second column on the right gives 200 per cent, based on a pre-war price of 100 per cent.

The importance of platting and studying the price-of-oil curve and the commodity-price curve in controlling production cannot be overemphasized. Had this been done in the case in point, there would not have been such overproduction between 1876 and 1892, and such a consequently wide margin between the price of oil and the commodity price. The price of oil, as is clearly indicated, should normally correspond closely to the commodity-price curve.

Since it rarely occurs that we have such complete records or such a prolonged period to deal with, these curves are really unusual, and their study should be profitable.

The ideal production curve in Fig. 2 shows how, under circumstances of control, the drilling might have been retarded so as to conform to the commodity price and conserve the oil. The maximum production would then have been in 1920, instead of in 1894; and the entire life of the field prolonged to 1940, instead of terminating in a much briefer period.

The total production of the Lambton fields is estimated as given in the following table:

	Barrels
Estimated loss 1861	5,000,000
Official records, 1862-86	4,610,945
Official records, 1886-1922	15,583,000
Total production	25,193,945

The authorities from whom these production figures have been taken are as follows: 1861, Prof. Alexander Winchell; 1862-93, F. G. Clapp; 1893-98, Ontario Bureau of Mines; 1898-04, Imperial Oil Co.; 1904-14, C. W. Knight, and 1914-23, Ontario Bureau of Mines. The authorities for prices from 1861 to 1923 are *Mineral Resources, Mineral Industry,* and *Derrick Industry.*

Discussion

"Engineering and Mining Journal-Press" is not responsible for statements or opinions published under "Discussion." In many cases the views expressed are diametrically opposed to editorial policy and belief.

In Favor of a Department of Mines

THE EDITOR:

Sir—It seems to me that the communication in your issue of April 19, 1924, "Against a Department of Mines," fails in proving the point that a department would increase the burden of reports and statements required from an operator. Could it be possible that a great deal of the overlapping and duplication of effort now in force would continue if one department had direct charge of all matters relating to mining? Does your contributor sincerely believe that with a man like Herbert Hoover as Secretary of Mining we would be worse off than we are at present?

The engineers who have advocated a Department of Public Works have advanced good arguments for the necessity of systemization in governmental affairs, and I am convinced that so big a business as that of our United States can be vastly improved by gathering, under one head the activities which are now scattered among so many bureaus and are causing the mine operator trouble in complying with the regulations imposed.

Although the substance of the quoted portion of ex-Senator Beveridge's speech is admittedly true and calls attention to the serious defects of bureaucratic government, it does not follow that defects of which we are all well aware cannot be remedied, and I believe that a large majority of the mine operators and mining engineers are in favor of the creation of a Department of Mining. F. L. SIZER.

San Francisco.

Financing the Prospect

THE EDITOR:

Sir—I have just read the article "Financing the Prospect," by Arthur B. Parsons, in your issue of April 26. It is exceedingly well done. The methods of the wily promoter and the smooth stock-salesman were never more entertainingly exposed. As the article says, the gentry flourishes chiefly upon the cupidity of men, not their ignorance. Promise a man a hundred for one and half convince him of it, and you can sell him anything; if you tell him a straight story and offer a fair gamble, he is not interested.

Much of the mining and oil stock that is foisted upon the public is not sold by tricksters, but by over-enthusiastic men and women whose ignorance of values enables them to make the most extravagant statements concerning their wares.

The evil—and it is a serious one—is not easy to cope with. After watching the game attentively for many years and endeavoring to devise some method of curbing it, I have arrived at the conclusion reached in this article, that the only practicable remedy is the "blue-sky" law.

The California law, on the whole, has worked very well. The commissioner is given wide powers, but has endeavored to use them fairly. Men who are promoting honest enterprises are put to considerable trouble and expense to obtain permits to issue and sell stock, but, on the other hand, it is safe to assume that the investing public has been saved millions of dollars by the interference of the commissioner with improper promotions. GRANT H. SMITH.

San Francisco.

Petroleum and Coal

THE EDITOR:

Sir—Replying to the criticism of your correspondent W. J. S. in the *Mining Journal-Press* of April 5, I will say that his list of the distillation products of organic matter can only be obtained by laboratory means which do not obtain in nature and are dehydrated by caustic soda or concentrated sulphuric acid or some dehydrating means which is impossible under natural conditions, as when a bed of coal is metamorphosed from bituminous into anthracite. They are just as artificial as metallic sodium and under atmospheric conditions revert to the hydrated form and are not petroleum, which is the matter under discussion.

What W. J. S. has broadcast about CH_4 arouses pleasant memories of elementary chemistry, but CH_4 is not petroleum and not pertinent to the discussion.

Coming now to that part of his criticism which he admits is mere juggling with symbols, we can subject it to the acid test on a large scale. A coal bed is one of the largest collections of organic matter in nature's storehouse and contains probably every variety of organic matter for which the most enthusiastic juggler of symbols with algebraic tendencies could write a formula. If petroleum were derived from coal by geological process, which would include metamorphism by heat, then the heat, coming from below, would drive the products of distillation upward, and the resulting petroleum should be found above the coal. On the contrary throughout the Appalachian and Mid-Continent fields, wherever coal and petroleum occur, with few exceptions, the petroleum comes from a few hundred to over a thousand feet below the coal, and in isolated and restricted pools, whereas the coal may be continuous beneath large areas from which no petroleum is drawn. The few exceptions where petroleum occurs at the surface or above the coal are only the well-known seeps which flow from the source below the coal along some fracture to the place where found.

In many places, such as California and Mexico, where petroleum occurs most abundantly, coal is absent. The fact that dry holes have been and often are drilled within a short distance of gushers suggests that petroleum is intrusive into the rocks in which it is found. This would follow upon an expansive force

from below in the same manner as a dike is intruded, and in case a porous medium, such as a sand, is encountered, covered by an impervious shale, the petroleum spreads laterally from the fracture and fills the sand pores. The shale stretches without fracture and the fault or fracture is mashed and does not appear at the surface. In this case, the most productive wells will be those nearest the fracture, and the direction of the fracture up which the petroleum came can be determined in a region that has been producing for a long time by the wells which continue to produce after the others have been abandoned. HIRAM W. HIXON.

Montreux, Switzerland.

L.O.X. Calculations

THE EDITOR:

Sir—The letter of Mr. Perrott in your issue of April 12 is welcomed as a response to my request for information, particularly from the Bureau of Mines, as to the speed rate of different materials the possibilities of which, as demonstrated by theoretical calculations, appeared worthy of attention.

Mr. Perrott does not yet give speed rates for the definite mixtures examined, but some general rates which do not help materially, as will be seen from a consideration of the variations in ballistic effect of cartridges of identical composition, except for the differing proportions of oxygen and carbon, in his valuable Table 3. But his suggestion of the gasification of alumina is extremely interesting and will, I trust, be verified. Mr. Perrott's conclusion appears at variance with the French Commission's graph dealing with aluminum-containing cartridges, but it would account for the extraordinary efficiency of such cartridges in breaking down the "loups" formed in steel furnaces.

In his eagerness to show the necessity for considering volume in determining "stick-for-stick" efficiency, Mr. Perrott would appear to have unintentionally done himself some disservice. My contribution was published because I considered "calculations as to the theoretical efficiency of certain combustibles" might be of special interest just now, and I added "this method (HV calculations) . . . is approximate only and is modified by the greater wave speed of dynamite and by the greater space occupied in the drill holes by the stiff light liquid oxygen cartridges."

In trying to get down to "stick-for-stick" calculations, Mr. Perrott has scarcely paid sufficient attention to the sentence above quoted.

We have to face the fact that in holes in very hard rock we have found that carbon-oxygen cartridges bulk so greatly as to leave insufficient space for the necessary stemming: the calculations showed that the use of naphthalene, cellulose, and possibly of aluminum, might be of service in this connection provided their wave speed were sufficiently high.

Mr. Perrott confirms my three conclusions and shows:

1. That dynamite, even after making his density allowance, has a relative value (theoretically only of course) of only 69 to cellulose 102, naphthalene 100.5, and carbon 100, with cartridges containing just enough oxygen for perfect combustion (Table 2).

2. That cellulose and naphthalene, after making his "volume" allowance, are theoretically more effective than carbon; and

3. That an excess of oxygen over that required for perfect combustion reduces the force of the explosive. Indeed, he demonstrates this conclusion of mine so effectively in his Tables 2 (second part: 0.3 gram excess oxygen) and 3, as almost to compel a desire for oxygen helmets, so that work might take place in an atmosphere of carbonic oxide in view of the higher efficiency of the minimum possible ratio of oxygen.

In conclusion I would again refer to my sentence as to the modifications resulting in practice from the greater space occupied by stiff light cartridges. I did not and still do not attempt to calculate "stick-for-stick" comparisons; wave-speed determinations will help us to the most effective cartridge for dealing with varying conditions of hardness of rock, cheapness of combustible and absorbent, and local cost of liquid oxygen; but a "stick-for-stick" comparison needs more than a mere correction for density. We have to face the fact, which Mr. Perrott omits to note in his remarks on maximum packing density, that the plasticity of gelatine dynamite avoids the empty spaces caused by the rigidity of frozen cartridges and by the method of firing these. Such spaces are not only detrimental to effective impact; they occupy room otherwise available for stemming. Mr. Perrott can no more afford to disregard stiffness (plasticity) than lightness (density); both mean volume.

In "Liquid Oxygen in Mining" (London, April, 1923), I showed that in practice a carbon-oxygen cartridge (measuring 1.38x12 in.), weighing at time of explosion 226 grams, equaled in actual effect a cartridge of 40 per cent dynamite measuring 8x1¼ in. and weighing 255 grams. Allowing for the voids due to the stiffness and to the method of detonating L.O.X., the latter is thus shown to require nearly twice the space required by 40 per cent dynamite for equal effect.

London. ALFRED JAMES.

The Voting Problem

THE EDITOR:

Sir—In your editorial "The Engineer as a Citizen," in the March 1 issue of the *Mining Journal-Press*, you make it appear that the members of the American Institute of Mining and Metallurgical Engineers are very lax in their duty in voting on the Institute's affairs. Lately the liberal press of the country has been getting after the citizens for their failure to vote at the polls, saying that they are slackers in their duty as citizens and that if anything goes wrong with our affairs they have no one to blame but themselves. I, for one, do not believe that the members of the Institute or the citizens are so much to blame as many seem to think. There is a very general misunderstanding of the difficulties in the way of a citizen or of a member of an organization giving adequate expression to his will. There is also a very general misunderstanding, as is shown by the current discussion of the Teapot Dome affair, of the difficult position in which an official of a government or any other organization is put by the present methods of voting.

There is in fact a very general misunderstanding of the nature of the difficulties in the way of all present-day government, whatever its character. The difficulties are not inherent, but are of our own making.

I have put in a lot of time and thought on this question, and I think I have discovered things about it that if generally known would place the whole subject in an entirely different light and would make us all more inclined to forgive and forget a great deal of the

apparent shortcomings in our fellow citizens and in our officials.

For instance, it is not generally known that by majority voting an official is put into a position of choosing between two evils; theoretically, he is supposed to work in the interests of all equally, yet he is forced, in his own interest, to favor some more than others because by the principle of majority voting an official's election is made to depend on the influence of some particular party. The principle of majority voting does not make an official's self-interest identical with that of the whole people or with the whole membership of an organization, but only with that of a part. Even if an official wished to serve the whole, he would, by the principle of majority voting, in his own interest, have to serve the interests of those who were the most influential in his election.

The situation is made still worse where we have a delegate system. The official is then elected by a majority of a majority; the more compounded the less sensitive and responsive an official must be to the welfare of the whole and the more sensitive and responsive he must be to a very small part—the part that was the most influential in his election.

It is from a situation like this that the demand for direct voting arises. Here is another difficulty created by majority voting: To adopt direct voting is to avoid one difficulty only to run into another. Those who stress the evils or difficulties of delegate government, but fail to see the difficulties of their own position, fail to understand the limitations and the difficulties in the way of a people or a membership in making intelligent selection of officials or voting intelligently on laws. They resist any attempt to point out these limitations. These limitations are in no wise a discredit to a people or a membership; they are placed on the most capable as well. It is right in the very nature of things. Take, for example, the selection of officials for the larger political divisions; owing to a people's sphere of acquaintance being limited to only a small locality, they are only able, at the very best, to make intelligent selections in that locality. The selection of officials for the larger political division must be delegated to a few who will make a special business of it.

Here is a dilemma: If we have direct voting, we suffer from the unintelligent lawmaking. On the other hand, if we delegate the selection of officials and the making of laws, the control over our officials will slip from our hands and we will have something like a majority of a majority of a majority rule. We are in this case, by the principle of majority voting, put in a position of having to choose between two evils; however we choose we will wish we had chosen the other way.

Taking another example of this limitation, that of selecting men for offices requiring skill and technical ability for the smaller political divisions. Even in a small locality the people are not in a position to make intelligent selections for offices requiring special skill and technical ability. This is so because the people are so occupied with the business of making a living and at occupations that call for a knowledge of things far different from what they are called upon to judge. This limitation is in the very nature of the division of labor on which so much of our prosperity is built. Again here, as in making intelligent selection for the larger political divisions, we must delegate the task to a few who will make a special business of making these selections. The principle of the Short Ballot is applicable here.

Here is another dilemma. If we select all the officials of the smaller divisions by direct vote we suffer from unintelligent selections; if we delegate the selection, as in the Short Ballot, we, by the principle of majority voting, put too much uncontrolled power in a few hands —hands not made sensitive and responsive to the interests of all equally. Whatever choice we make there is some serious objection to be made to it.

I think it will be seen from this that the failure of a member of an organization or of a citizen to take an active and an effective part in the affairs of his organization or of his government is not due to any laxness or moral shortcoming on his part, but is due primarily to a faulty principle of voting. Naturally, when a member cannot make his voice felt and his interests are not promoted, he ceases to take interest. His heart will be where his interests are promoted. Majority voting produces an effect equivalent to absenting the minority. And when there is a delegating of powers it has an effect equivalent to absenting a majority.

What is the remedy? Is there a way out of this dilemma that the principle of majority voting creates? I believe there is.

Whatever consideration is given to the rights of the minority by the majority through our officials by this principle of voting is not due to anything in it legally compelling such a consideration but to a feeling that they are morally obliged to give it. Legally the entire influence of the minority is canceled. They are put absolutely at the mercy of the majority. The problem is how to make the influence of the minority, or any part, legally felt. I believe this can be done by employing the principle of concurrent voting in voting for our officials. A form of this principle of voting is used in selecting a jury from a panel from the twenty-four men. In concurrent voting each voter's vote has an effect equal to any other's. It is not canceled or thrown away and made negligible as in any majority-minority voting system. With concurrent voting we could have a compound delegate system and the Short Ballot, with all their advantages, without losing control of our officials—without the evils of majority voting.

Prescott, Ariz. WILLIAM CROCKER.

Rubber Impellers in Flotation Machines at Utah Copper

THE EDITOR:

Sir—Your recent article in the *Mining Journal-Press* concerning the new use for rubber found by James J. Denny, metallurgist for the Nipissing Mining Co., brings to my mind a fact with which no doubt you are already familiar, but which perhaps is worth restating here—namely, that the Utah Copper Co., in its flotation mill near Salt Lake, has found that rubber agitator arms in its flotation machines are far more durable and satisfactory than the cast-iron arms previously used. On the basis of experiment the company equipped its entire Magna and Arthur plants with these rubber agitator arms, and I believe that it also has been experimenting on rubber for its ball- and tube-mill linings.

New York. M. O. LOKENSGARD.

News of the Week

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Summary

TONOPAH BULLION shipments of $402,000 for April exceeded those of any month since July, 1923, when the Pittman Act purchases were completed. The Tonopah Extension company has established a new production record.

The Senate Gold-Silver Inquiry is being continued in spite of criticism, on the ground of economy, in the Senate.

Valuation for tax purposes of Michigan copper mines has been reduced about $13,500,000 for the current year.

The Northern Peru Mining & Smelting Co., an A. S. & R. subsidiary, has started its new Diana flotation and concentrating plant.

Five miners entombed for three days in the mine of the Empire Zinc Co. at Gillman, Colo., have been rescued.

H. F. Marriott, of London, has a plan to decrease the overhead cost of mine promotion in the Empire.

The output of gold from the Rand mines during March totaled 795,671 oz., an increase of 35,054 oz. over February.

Shipment of high-grade ore has been started from the B. C. Silver mine, adjoining the Premier in British Columbia.

A production of 2,500,000 lb. of copper from the new Magma smelter in April exceeded estimates by 500,000 lb.

The proposed acquisition of the hydro-electric projects of both the Northern Ontario Power Co. and the Hollinger Consolidated Gold Mines Co. by the Insull interests would end the controversy between the two.

Electrically operated shovels and locomotives are becoming increasingly popular on the Mesabi iron range, in Minnesota.

Congressman James has introduced a bill in Congress providing for a 6c. tariff on copper.

Tonopah Bullion Shipments Best Since Those of July, 1923

Tonopah Extension Breaks Own Record With $223,452 in April—Belmont Develops IOU Vein

April bullion shipments from the Tonopah district had a value of approximately $402,000, the largest since July of last year. The Tonopah Extension shipped bullion valued at $223,452, the West End $68,680, and the Tonopah Mining Co., which included Belmont production for the month, $110,000.

The outstanding feature of the month was the continued accelerated production by the Tonopah Extension Mining Co. This company shipped 278,315 oz. of bullion, valued at $223,452, which is the largest in both ounces and value in the history of the mine. Tonnage milled was 14,400 tons, and per ton value was about $16.50.

The Tonopah Extension is sinking the Cash Boy shaft, and the bottom of the shaft is already more than 100 ft. below the 2,000 level. Shaft sinking is to be continued to the 2,250 elevation, with levels at 2,125 and 2,250. The grade of ore on the 2,000 level is better than above.

The Belmont reports satisfactory development on the IOU vein on the 900 and 1,000 levels. The vein has not yet been located on the 1,100 level, but the crosscut is nearing the projected position of the vein on that level and should cut it soon. Belmont production in April was 3,417 tons of ore, from which over $70,000 worth of bullion was realized. This is the largest production for many months for this company.

The West End reports continued active development work in West End Extension and Tonopah "76" territory. The "76" vein is being developed by east and west drifts, two raises and a winze. Ore saved from this development has been shipped to the West End mill, but mill returns are not available. Crosscutting in the West End Extension ground has exposed many stringers which carry good values.

Hoisting Rope Transported by Airplane in Ontario

FOR the first time in the history of northern Ontario mining, airplanes were recently used for the transportation of materials. A few days ago one of the companies operating in the Rouyn district of western Quebec wanted a hoisting cable delivered immediately. Ordinary methods of transportation by land and water, which at this time of the year would involve considerable delay, were too slow, so the cable was sent in by plane.

Calumet & Hecla Copper Stocks Worth $5,198,253

Permanent Rails in 81st Level Haulageway—Good Rock Developed in Deepest Levels

According to the report of Calumet & Hecla Consolidated Mining Co., operating in Michigan, for the first quarter of this year, the company had approximately 38,500,000 lb. of refined copper on hand April 1. This, based on present curtailed production, is equivalent to about seven months' output. For the first three months of this year, Calumet & Hecla's sales have almost kept pace with production. Copper on hand on Jan. 1 was valued at $4,816,494.63 and that on hand on April 1 was carried at $5,198,235.20.

In the conglomerate department of Calumet & Hecla, permanent rails have been laid in the haulageway at the 81st level from the Red Jacket shaft to No. 12 shaft, the southern terminal. Trolley wires also have been strung and crosscuts are being driven to the several shafts in the Hecla end of the property. The haulage level will be put in operation as soon as possible, which will greatly facilitate operations at depth and permit the deepening of the Hecla shafts Nos. 6 and 7, which already are below the 81st. Rock of splendid value is being opened in the deepest levels in these shafts.

B. C. Silver Mines Ships High Grade from Premier Vein

Neighbor, Owning One-third Stock, Unable to Co-operate in Handling Ore—Selukwe Interested

B. C. Silver Mines, owning property adjacent to the Premier, in British Columbia, has issued a notice to its shareholders, stating that it has begun to raise on the oreshoot developed in No. 3 tunnel and that high-grade ore is being sacked for shipment. The average value of the ore in the shoot is about $40 per ton in gold and silver, but assays have shown as high as 51 oz. gold and 261 oz. silver per ton. It is this high grade that is being sacked.

It was hoped that arrangements could have been made with the Premier Gold Mining Co., which owns considerably more than one-third of the outstanding stock of B. C. Silver, to handle this ore either along its tramway or through its mill, in which event the ore would have been passed from B. C. Silver No. 3 to Premier No. 2 level, and thence to the mill or tramway, but just now the Premier mill and tramway is being operated at capacity on the company's own ore. So, for the present, B. C. Silver will ship only the high-grade ore.

B. C. Silver claims lie north of the Premier holdings, and two years ago last February it cut the main Premier vein, at a depth, however, that seemed to be below the level of secondary enrichment. An oreshoot was found near the Premier line, but as this appeared to dip into Premier territory, exploration was directed in the opposite direction. Since then the company has driven a higher tunnel and now will connect the two tunnels by a raise, which will be put up on the shoot near Premier territory, which gets farther and farther into B. C. Silver territory as it ascends.

B. C. Silver has been plugging pluckily at development, despite many disappointments, and now it may realize on its labors. It may be remembered that when the company cut the Premier vein the shares of Selukwe Mining & Finance Co., the holding company for B. C. Silver, made some sensational advances on the London market.

Ellensberg Mining Co. Plans 20-Stamp Mill

The Ellensberg Mining Co., operating near Santa, Idaho, plans the erection of a 20-stamp mill. The mine is in the Camas Cove district at the head of Beaver Creek.

According to reports of officials of the company a wide vein is being worked; walls of porphyry and schist can be traced for a mile through the country. It is supposed to be the source of the gold in the Tyson placers below, which were worked fifty years ago by pioneer operators.

According to reports high assays have been obtained. The property has been developed on the surface by open cuts and shafts. It was located in 1910 by John Lawless, of Santa, Idaho, president of the Ellensberg company. The district has produced rich placer gold.

Alleged Ore Salter at Garfield Smelter Acquitted

ORE-SALTING cases are not common nowadays, so that the recent acquittal of James McCoy at Salt Lake City of that charge is of some interest. McCoy was accused of conspiring with W. H. Connors, who was alleged to have done the actual salting, to defraud the Garfield Smelting Co. A car of ore had been shipped by Connors from the Warm Springs district in Nevada, and it was charged that the sample had been sprinkled with gold dust. A modern touch to the story was that some of the evidence in the case was obtained by dictograph, and recorded by a dictograph detective. This testimony was held to be unreliable by the defendant's attorney, who based his argument in part upon a recent magazine article by Sir Basil Thompson, formerly head of Scotland Yard.

This Sheik's Victims Form Committee to Save Wreckage

The California State Corporation Department announces that a state-wide search is on for J. A. Sheik, who is under an indictment for obtaining money and property by false pretenses. The indictment was returned following an investigation of the affairs of the Monarch Rand Mining Co. An examination of the company's books disclosed that approximately $336,000 had been received by Sheik and others in the pre-organization campaign of the company. No money is on hand and the company is in debt.

The Monarch Rand's properties are near Randsburg, Calif., and the company's headquarters are at Bakersfield. Among the misrepresentations attributed to Sheik in his campaign for money were that no charge would be made for commissions for the sale of stock; that the sale was under the direction of the Corporation Department; that there would be no bonus stock; that he had paid in $25,000 to carry on the work, and that there was $1,000,000 in gold blocked out and ready to ship. The control of the company was recently taken from the men who formed it and placed in the hands of a committee of stockholders who are seeking to place it on its feet.

Lead Mines at Elliston, Mont., Will Be Reopened

The Eureka and Little Dick mines, at Elliston, Mont., under the supervision of C. O. Bielenberg, were reopened on May 15. The equipment has been overhauled, and all necessary deadwork completed.

The management expects to have a crew of thirty men by July 1, and to ship 100 tons of ore per day. Both mines have been good lead producers in the past. It is stated that a fair tonnage of ore averaging 26 per cent lead and $10 gold is blocked out.

Electrically Operated Equipment Gains Favor on Mesabi Range

Shovels and Locomotives Both Run by Electricity—Caterpillar Tractors Also Popular for Shovels

The increased use of electrically driven machinery in the mining and transportation of iron ore in the Lake Superior district, and especially on the Mesabi range, is an important development. At present there are five electrically driven shovels of the 300- or 350-ton class in use, and two orders have been placed for shovels of a lighter type which are to be electrically driven. The Hanna Ore Mining Co. has placed an order for a 50-B electric driven shovel with caterpillar tractors. This shovel will be the first one of the smaller type using direct current. The current will enter the shovel as alternating at 2,200 volts and three phase to a 65-kw. motor-generator set, which in turn will supply the direct current to the three separate motors. The second electric shovel which has been ordered by the Wisconsin Steel Co. will be of the 30-ton class and will use alternating current at its two motors. It will also be equipped with caterpillar tractors and be of the full revolving type.

Besides the shovels several orders call for electric locomotives of standard gage for open-pit operations. The Hanna Ore Mining Co. has placed an order for three electric locomotives from the General Electric Co. They will be of the trolley type, weighing 65 tons, and will be used in the open pit, both for stripping and ore operations.

The Oliver Iron Mining Co. has received and placed in operation a 20-ton electric locomotive in its Virginia district. This locomotive is also standard gage and will handle 20- and 30-yd. dump cars in disposing of waste material at the new crushing and screening plant with an average haul of 1,000 ft.

Five Miners, Entombed, Are Rescued After Three Days

After being imprisoned from Saturday afternoon until 9 o'clock Tuesday evening, May 13, five miners, who had been entrapped in a stope of the Empire zinc mine at Gillman, Colo., were released without injury and ready, one of them declared, to go back on shift after a night's rest.

On Saturday afternoon at 3:30 a run of rock in the big stope of the Black Iron mine cut off all means of egress and filled the drift for a distance of about 90 ft. In order to communicate with the five men working in the stope, a 1¼-in. diamond drill casing was forced through the debris, through which air and food were supplied to the imprisoned men.

Efforts to remove the debris were interrupted from time to time by further runs of stope filling, and after about forty-eight hours of effort it was found necessary to abandon the plan of rescue, and it was decided to run a drift through solid rock from another stope. Rapid progress was made through the solid rock until the last few feet, where the drift was holed through to the trapped miners.

Burra Burra mine of the Tennessee Copper Co.
The city of Ducktown is shown with the Big Frog Mountain in the distance.
Photo taken from Burra Burra mine office

Star Crosscut, 9,000 Ft. Long, Nears Objective

The Star crosscut, being run jointly by the Hecla Mining Co. and Bunker Hill & Sullivan Co. of the Coeur d'Alene district in Idaho, is nearing the Star vein, and a strike may be announced any day. The crosscut starts from the bottom of the Hecla shaft, 2,000 ft. deep, and its length is approximately 9,000 ft. This big enterprise was started about two and a half years ago and would have been completed last fall had it not been for the Hecla fire, which caused a complete suspension of work in the crosscut for six months.

In the development of the Star the two companies are operating under the corporate name of the Sullivan Mining Co., the stock of which is held on a 50-50 basis.

Consolidated M. & S. Co. Must Pay Neighboring Farmers

Sulphur Fume Damage Fixed by Arbitration Court—Company Raises Good Crop in Smoke Area

The arbitration court, which has been sitting at irregular periods for the last four years and has heard the evidence of fifty farmers who claimed damage to their properties from fume from the Trail smelter, in British Columbia, has ended its task. Half of the fifty claimants were content to accept the terms of settlement offered by the Consolidated Mining & Smelting Co. In the remaining claims the arbitrator, Judge J. A. Forin, of Nelson, found that varying amounts of damage had been done by smelter fume, and he awarded damages aggreating rather more than $60,000 accordingly. The four properties that had suffered most he ordered the Consolidated company to buy.

Most of the sulphurous oxide derived from the various roasting and smelting operations at Trail is allowed to escape into the atmosphere, and as the company produced nearly 50,000 tons of lead and 30,000 tons of zinc last year, almost entirely from sulphide ores and concentrates, the amount of sulphurous oxide evolved must have been great. The company has a considerable acreage set out in mixed farming within the polluted area, and there can be no disputing that the vegetation in this area is in an exceedingly healthy condition. Of course, more care is taken in cultivation and fertilization than is practicable with the average farmer.

Burra Burra Mine, at Ducktown, Has Twenty-fifth Birthday

Charles Skullman, Still "Boss" After Quarter Century, Celebrates with Tennessee Copper Co. Officials

Every mine reaches the age of twenty-five years, provided it is not worked out before, but it is rarely that a mine passes the quarter century mark in charge of the man who broke ground for its shaft when operations were first begun. On May 9, 1899, twenty-five years ago, three men, armed with pick and shovel, began sinking a shaft at Ducktown, Tenn. Thus began the operations of the Tennessee Copper Co. in the Ducktown basin. The shaft was the Burra Burra shaft, from that time up to the present the main hoisting shaft of the Burra Burra mine, the company's principal producer.

The foreman of the gang of three workmen was Charles Skullman, who continued as foreman of the mine as work progressed. Years later Skullman became captain of all the company's mines, including the Burra Burra, so that throughout the quarter century the latter mine has been continuously under his care. During this time 6,000,000 tons of copper ore has been hoisted up the Burra Burra shaft, the bottom of which is now more than 1,400 ft. below the collar, with the bottom of the mine not yet in sight.

The anniversary was celebrated by a visit of inspection to the mine by a party of executives, engineers, foremen and shift bosses, headed by M. A. Caine, assistant general manager. Upon coming to the top, a dinner in honor of Captain Skullman was served in the Burra Burra staff house. The day wound up with a ball game between the company's Ducktown team and the smelter team from Copperhill.

West End-Tonopah Ex "Apex" Differences Composed, Is Report

It is reported on good authority that the West End-Tonopah Extension litigation over apex rights on what is known as the North vein has been settled. Terms of settlement have not been made public, but it is generally known that the West End is to receive a cash payment and other considerations. The settlement of this litigation comes as good news to people interested in Tonopah, as previous experience has shown that taking these apex cases through the courts involves large costs and delay in operations.

Dome Deepens Present Shaft; Abandons New Sinking

Though officials of the Dome Mines of Porcupine, Ont., are not prepared to issue any statement regarding the developments in the greenstone south of the porphyry, it is understood that results from this work have been favorable. That this is the case is indicated by the fact that the company has abandoned, for the time being, the proposed new shaft, which was to have been sunk near the Dome Extension boundary, and instead is continuing the present main shaft to 1,840 ft.

The company is maintaining its mill heads at about $9 a ton, and is recovering approximately $355,000 a month. During the coming months costs should be somewhat lower than under winter conditions.

Hollinger-Northern Ontario Power Controversy May End

Insull Interests Will Take Over All Hydro-Electric Projects, Is Report —Hollinger Mills 5,000 Tons

It is understood that the Insull interests, who are the biggest power people in Chicago, are completing negotiations for the taking over of the properties of the Northern Canada Power Co., which supplies power to the gold mines of the Porcupine district, in Ontario. If the transaction is completed, it will be the most important news in nothern Ontario mining circles for some time, as it will no doubt lead to a settlement of the long-drawn-out power litigation between the power company and the Hollinger Gold Mines. There is also some ground for the belief that the Insull interests will also take over the Hollinger power development.

The Northern Canada Power Co., which is controlled by the Fasken interests of Toronto, has a number of plants with a capacity of 29,000 hp. A new development on the Quinze River in Quebec is being completed, which will supply an additional 20,000 hp., and the company controls further power sources of approximately 40,000 hp. If the Hollinger were to continue with its power development it would have to provide for an expenditure of approximately $4,000,000.

The Hollinger mill is now treating about 5,000 tons a day, and earnings are considerably in excess of dividend requirements. Current liquid assets approximate $8,000,000.

High-grade ore sacked for shipment

The Plaza at Trujillo

A. S. & R. Subsidiary Starts New 150-Ton Mill in Peru

Bonanza Gold-Silver Ore Concentrated and Cyanided—Twofold Development, Costing $5,000,000, Will Include Copper Smelter—Another Project of H. A. Guess'

By Arthur B. Parsons
Assistant Editor

SILVER-GOLD ore richer than much of the concentrate that is shipped to American smelters will, at the start, be the mill feed for the new 150-ton concentrating and cyanide plant that will be put in operation before June 1 by the Northern Peru Mining & Smelting Co. for its Diana group of mines. I have seen assay reports, but am not at liberty to give the figures, except to say that the ratio of silver value to gold is about 3 to 1. This is only the *second-grade* ore, from which direct smelting ore has been sorted for shipment to the Selby smelter on San Francisco Bay and from which profits of about $1,500,000 were realized during 1923.

This unusually rich ore comes from a strong vein 3 to 5 ft. thick that already has been developed along the strike for several thousand feet. With all due respect to South Lorrain, California Rand, Park-Utah, or any other contenders, this has promise of developing into the richest silver-gold bonanza since the Premier was opened in British Columbia.

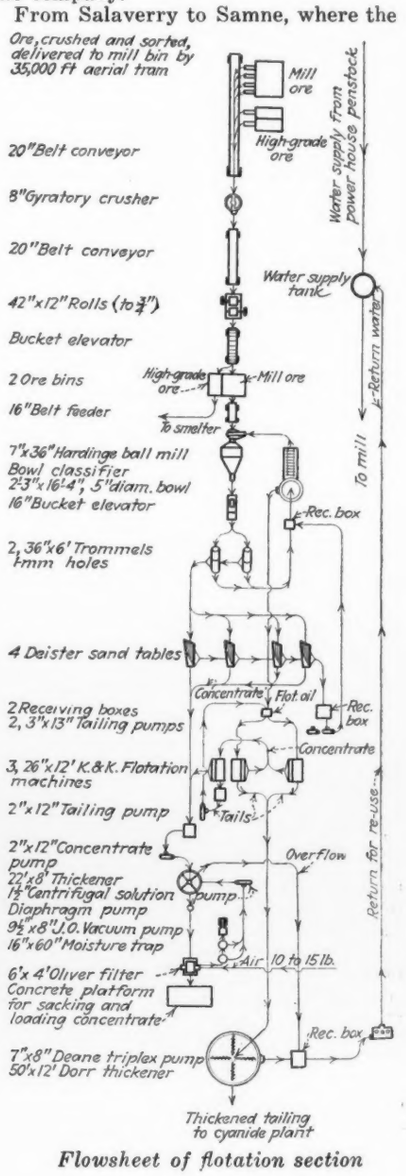
It is a long way from the Premier to northern Peru and a long way from either to the northeast corner of the thirty-fourth floor of 120 Broadway, yet it happens that just there one usually can find the guiding spirit of both enterprises, the engineer who recognized the possibilities of both when they were still infants, as mines go. The name on the door of the corner room is H. A. Guess.

The Northern Peru company is a subsidiary of the American Smelting & Refining Co., and Mr. Guess, as vice-president and head of the mining department of the parent company, is vice-president and managing director of the subsidiary. The latter was organized in 1921 to take over sundry options and operating agreements in the Province of La Libertad, in the mountains east of the port of Salaverry. The properties involved included the Quirurvilca and Almiranta copper deposits, in which a large tonnage of 8 per cent ore containing silver and some gold has been developed, and a number of silver-gold mines centering at Salpo. The principal options, which ran for three years, were exercised while Mr. Guess was in Peru during March of this year. The most important silver-gold mines, the Diana and La Guardia groups, are being operated on a share basis by the Northern Peru company, and it is from the former that the rich shipments have been made to Selby. The profits are approximately halved by the Peruvian owners and the N. P. M. & S. Co. All of the territory in the vicinity has been acquired either in whole or in part by the company.

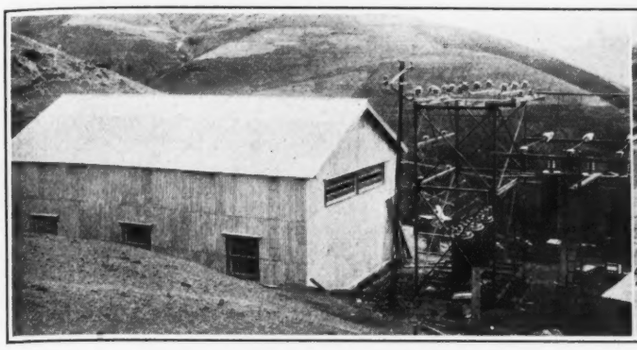
From Salaverry to Samne, where the

The new mill at Samne

This photograph was taken in January while much of the equipment was yet unhoused. Note the "draw" in the background where the tailings will be deposited



Flowsheet of flotation section



Transformer station at Salpo

Peruvian buildings at Milluachaqui

new mill is situated, is a distance of about 45 miles. The railway of the Peruvian Corporation extends as far as Quirihuac and a good auto-truck road, 20 miles long, connects Quirihuac with Samne. The silver-gold mines are 8 miles from the mill and are connected with it by an aerial tramway, which has just been completed. Samne has an elevation of 5,000 ft. and Salpo is 5,500 ft. still higher up. Obviously the construction of a railroad in the mountains would be an extremely costly undertaking, and the aerial tramway as a means of transportation is an important factor in reducing the initial investment as well as in making for low operating costs.

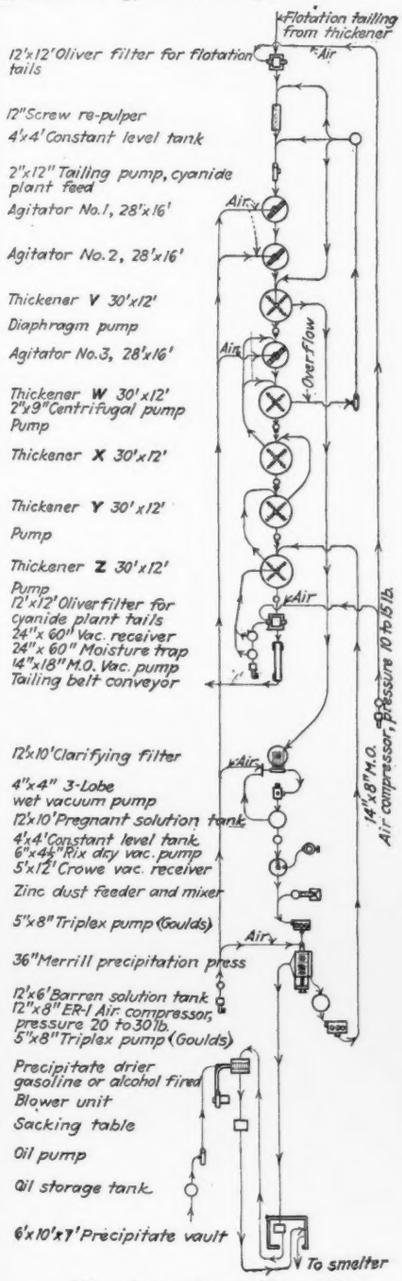
Quiruvilca has an elevation of 12,500 ft. and is 20 miles farther eastward. An extension of the tramway to the copper mines will be one of the projects to be completed during the next twenty months. Plans for a pyritic copper smelter of 300-ton daily capacity near the copper mines are drawn, and construction will be pushed as rapidly as possible, with the expectation of being ready to blow in early in 1926.

The company owns a coal mine, only a few miles away, which will provide fuel for smelting purposes. Siliceous ores from the gold-silver properties, to be used as flux, will be conveyed to the smelter by the aerial tramway, and the resulting blister copper will be started on its way to the coast over this same tramway, by which it will be delivered to the lower terminal at the Samne mill.

Copper production is estimated to be about 1,500,000 lb. per month. Transporting blister, together with the fluxing ore and gold-silver concentrates —if it is decided to smelt them at Quiruvilca—and incoming supplies, will give the tramway plenty to do. The total investment when this program of development and construction is complete will be about $5,000,000.

Hydro-electric power will be generated near Samne. One 1,250-hp. unit is now running and a 1,300-hp. unit is being installed. Allis-Chalmers water wheels operating under 1,480-ft. head are direct-connected to the generators. A high-tension transmission line carries the current to the substation at Salpo, where it is transformed for use at the mines.

The mill design was based on tests made in the United States by the mining department of the A. S. & R. Co. It resembles that of the Premier in many respects. As indicated in the accompanying flow sheets, the treatment combines concentration of the sands on Deister tables, concentration of the slime in K. & K. flotation machines, and cyanide treatment of the flotation tails, by agitation, counter-current displacement of the rich solution, and filtration. The table tailing is to be returned to the grinding circuit. The cyanide tailing will be disposed of by belt conveyors, which will carry it to the deep wash shown in the accompanying photograph. Preliminary crushing and sorting will be done at the mine, the direct shipping and milling ore being



Flowsheet of cyanide section

General view of Salpo, where the silver-gold group of mines is situated. The copper mines are twenty miles farther east

Michigan Mine-tax Valuations Are Largely Reduced

THE Michigan State Tax Commission, at a hearing in Houghton on May 15, fixed valuations of mine properties in Houghton and Keweenaw counties for taxation purposes at $25,485,750 for Houghton County and $13,218,921 for Keweenaw County. This is a reduction of $10,485,213 for Houghton County and $13,218,921 for Keweenaw.

The new valuations are based on actual physical valuation, the commission abandoning the average stock value method used in previous years. Valuations are for mine properties only and do not include other property owned by the companies.

delivered by tramway to separate bins at the mill.

On account of the moderate altitude living conditions at Samne are better than either on the tropical coast or at the mines higher up in the mountains. A novel feature is the erection of comfortable portable houses, made in

One of the portable houses, before the front yard was cleaned up

the United States, for the American officials and employees. The labor is entirely native, but the inhabitants are not without experience at mining, as the silver-gold mines have been worked more or less successfully for the last seventy-five years.

The main offices of the company are at Trujillo, a larger seaport town north of Salaverry. Preston Locke, as general manager, is in charge of all operations in Peru, and R. E. Douglass is his assistant.

Mr. Guess returned recently from a month spent at the mines. He is never given to verbal exuberance, but under the stimulation of interrogation he enthused enough the other day to say, "We certainly have *some* ore," with an emphasis on "some" that indicated unusual quality or quantity, or both. A good guess is both.

Butte & Superior Ships 1,325 Tons per Day

The Butte & Superior Mining Co. is shipping from its Black Rock mine, at Butte, an average of 825 tons of zinc ore and 500 tons of copper ore per day, to the Washoe plant of the Anaconda Copper Mining Co.

London Letter

By W. A. Doman

Special Correspondent

Marriott Proposes to Cut Cost of Mine Promotion

Would Economize on "Administration" Expense and Give Share Purchasers a "Run for Their Money"

London, May 6—Hugh F. Marriott, as a result of his trip to Australia, and return through Canada, has conceived certain views concerning mining promotion, and intends to put them into practice.

He is of the opinion that mining promotion could be done much less expensively than heretofore. Since his journey to Greece to investigate a property there, he has been to Monte Carlo, not for the purpose of gambling but to catch a principal interested in mining. Mr. Marriott has taken an office in Broad Street Place, and has formed a small syndicate with a capital of about £20,000. In itself, this sum would not go far, but his reputation is so high in the profession that when needed he can call upon associates for sums aggregating £500,000.

It must be admitted that with his South African and London experience Mr. Marriott is not ignorant concerning company promotion. He says that too frequently capital is subscribed before a property is adequately tested, the result being that the public does not always get a fair run for its money, and that a large percentage of it is swallowed up in administration expenses. He intends trying the reverse process. The money subscribed to his small initial syndicate will, he says, be sufficient to test any property by drilling, and this he would do from boundary to boundary. The showing would, in his opinion, decide whether further outlay could be profitably incurred. Overhead expenses would be negligible. This would be a novel way of doing things, and if, subsequent to testing, vendor considerations were not heavy, the capital account could be kept down, with benefit to subscribers if and when there is any profit to divide.

Rumors of an amalgamation of two leading firms of copper manufacturers are now set at rest by the announcement that a provisional agreement has been signed between Messrs. Vivian & Sons, Ltd., and Messrs. Williams, Foster & Co. and Pascoe Grenfell & Sons, Ltd., to form a new company to carry on the amalgamated businesses. Vivian & Sons is a private company, the shares being held by family interests. Williams, Foster & Co. and Pascoe Grenfell & Sons is a public company with an issued capital of £350,000, £100,000 in preference, and the balance in ordinary shares. The Central Mining & Investment Corporation is largely interested in this latter company.

The object of the fusion is to meet foreign competition. Both companies own extensive works, adjacent, near Swansea, as well as other works in the district. Both are large manufacturers of copper, yellow metal, and spelter; and the brass and copper tube business of Grice, Grice & Sons, Ltd., Birmingham, belongs to Williams, Foster & Co. The new company—capital not yet stated—will represent a very large proportion of the total copper manufacturing trade of the country.

In various directions endeavors are to be made to raise capital in London for the development of Canadian mineral resources. Hugh F. Marriott has written a series of three articles for *The Financial News;* Charles McCrea, Provincial Minister of Mines for Ontario, is over here to sing the praises of Canada from the mining standpoint, and Canadian Government agents are sending out much publicity literature. The general view is that much money will be gathered in London. The main argument put forward is that the United States is getting the plums in mining that ought to remain for imperial exploitation.

Keeley, in Northern Ontario, Netted $582,648 During 1923

THE annual report of the Keeley Silver Mines of the South Lorrain district in northern Ontario for the year ended Feb. 29 shows a production of 1,589,010 oz., compared with 760,690 oz. in 1922. Revenue from the sale of silver and cobalt was $1,060,198 and miscellaneous revenue brought the total receipts to $1,093,047. Operating expenditures were $400,889, and head office, legal expenses, taxes, and provision for depreciation brought the total deductions to $510,399, leaving net profits applicable to dividends of $582,648, amounting to a little over 29 per cent on the issued capital. Dividends paid during the year amounted to $750,000. Ore reserves are estimated at 3,742,954 oz., compared with 1,500,000 oz. for the previous year. The company has an issued capital of $2,000,000 and the present dividend rate is 24 per cent per annum.

Plans Small Customs Plants for Grants Pass, Oregon

Henry M. Lancaster, mining engineer, for many years connected with mining in the Coeur d'Alene district, and who is constructing a custom gold mill at Grants Pass, Ore., says that there are numerous small but very rich gold veins which have not sufficient tonnage to justify independent mills, but which in the aggregate provide ample tonnage for a customs plant. The first unit of the Lancaster mill will have a capacity of 25 tons per day, and he plans to add units when necessary until possibly 250 tons is reached.

A ball mill will be used for fine crushing and the free gold will be recovered by a Russell-Thayer centrifugal amalgamator. Mr. Lancaster's plans also include smelting and cyanide plants, each of five tons' capacity, to treat refractory ores.

Washington News

By Paul Wooton
Special Correspondent

Gold-Silver Commission Continues Plans for Investigation

Adverse Criticism in Senate Does Not Halt Work—Departments Would Have Been Too Slow, Is Answer

Lack of sympathy with any expenditure of federal money in the interest of Western mining is being evidenced by certain members of the Senate, who have shown great concern because the Commission of Gold and Silver Inquiry has expended $56,000. It happens that at the same time the Senate Committee on Appropriations has added a million dollars to the House Agricultural Appropriation bill. The committee looks with favor on additional appropriations in excess of the total amount expended in the gold and silvery inquiry for incidentals such as the study of the electrification of dust particles and the improvement of calcium arsenate manufacture in connection with boll-weevil control. The probabilities are that these Senators will offer no objection to the increases proposed for agricultural research, but, on the ground of economy, they are attacking the expenditures in the interest of gold and silver mining. The latest objection that has been dragged out, even in the face of a declaration on the floor of the Senate by the Democratic leader to the effect that none of the committee's expenditures has been "improvident or unwise," is that the work should have been done by the Bureau of Mines or the Geological Survey.

The critics of the inquiry have failed to take into account that the acts creating the Bureau of Mines and the Geological Survey do not extend to those agencies the authority necessary to deal with the subjects which have been assigned to the Senate Commission of Gold and Silver Inquiry. Much of the work of the commission is in the field of banking, finance, and economics. The commission also is authorized to "confer with citizens, associations or corporations of foreign countries with a view to the stabilization and wider use of silver in exchange," and "to propose to the President of the United States, or the heads of the proper departments, plans for negotiations with foreign governments to the same end."

Even had the Bureau of Mines and the Geological Survey possessed the legal authority to conduct the investigation, no funds would have been at hand for the purpose, and it would have required the enactment of appropriation bills to make the necessary funds available. The delay incident to a departmental investigation would have defeated the object of the effort.

It is not believed, however, that the criticism will be sufficient to terminate the inquiry, with its work only partly done. Regardless of the outcome of the attack which is being made upon it, the commission is continuing with its work and its plans. That the industry itself is much interested is indicated by the percentage of returns being received on the intricate questionnaire covering costs of production and the yield on investment. The yield on investment is to be compared with those of banks and insurance companies.

Bill for Copper Tariff Formally Introduced "To Protect a Great American Industry from Ruin of Foreign Competition"

A DUTY of 6c. per pound on imports of copper into the United States is proposed in a bill introduced by Representative James, of Michigan. The bill takes the form of amendment to the existing tariff act. Mr. James says a duty on copper is necessary to conserve one of our important resources; to enable the producers to pay a living wage to their employees; to enable the owners of American copper mines to secure the return of a portion of their investment and to protect the great American industry from ruin due to foreign competition. Representative James cites the serious situation in the Michigan Copper Country. He says: "In 1913, foreign copper was scarcely a factor in the domestic market; in 1923, over one-third of the copper consumed in the United States came from abroad. The copper mines of the United States cannot meet this foreign competition. Our mines operate under American conditions, they employ American labor, and pay an American wage scale. Foreign mines can produce copper for 6 or 7c. per lb. less than American copper mines. Unless there is a tariff on copper, within a few years there is no reason why foreign copper mines will not have absolute control of the American copper market."

The text of the amendment says:

"Copper ore of all kinds, copper concentrates, regulus, mattes, cement copper, and black or coarse copper, 6c. per pound on the copper contained therein; old copper, scrap copper, fit only for remanufacture; copper scale, clippings from new copper; blister copper, copper in plates, bars, ingots or pigs, not manufactured, and copper in any other form not especially provided for, 6c. per pound; all alloys or combinations of copper not specially provided for, 6c. per pound on the copper contained therein; provided, that such duty shall not be applied to the copper contained in copper-bearing ores or mattes unless actually recovered. . . ."

Mining Is a Basic Industry

The Senate last week passed a resolution declaring that agriculture "is the basic industry of this country." In the House an effort will be made to amend the resolution, so as to make it read "Agriculture and mining are the basic industries of this country."

The resolution was passed to direct the Interstate Commerce Commission "to effect such lawful changes in the rate structure of the country as will promote the freedom of movement by common carriers of the products of agriculture, including livestock, at the lowest possible lawful rates compatible with the maintenance of adequate transportation service." The House amendment will propose the inclusion of the products of mines in the resolution.

The legislation is nothing more than a gesture, as the Interstate Commerce Commission already has legal responsibility for doing just the thing toward all commodities as is suggested in the Senate resolution for agricultural products.

Boleo April Production 992,000 Lb.

The Companie du Boleo, the French company operating in Lower California, during April produced 992,000 lb. of copper from ore averaging 4.25 per cent.

New Magma Smelter Exceeds Expected Output by 500,000 Lb.

The Magma Copper Co. produced 2,500,000 lb. of copper during the month of April, the first full month's operation since the completion of the new smelter. This initial output of the new plant evidences its success and if that rate of production is maintained, the year's output will be 30,000,000 lb., or over three times as much as previous production.

Hercules May Get Control of Honolulu Mining Co.

At a meeting late in May of the stockholders of the Honolulu Mining Co., owning property near Wallace, Idaho, action will be taken on a proposal to deliver the control of the company to the Hercules Mining Co. in consideration of the latter company expending $50,000 in the development of the Honolulu and placing it on a productive basis. The Honolulu joins the Hercules on the north. On the east is the Ajax, on which an important strike was recently made. That is, the strike was actually made on Hercules ground, as recently explained in the *Mining Journal-Press*, and negotiations are still pending between the Hercules and the Ajax in connection with their respective rights. It is regarded quite probable that the Ajax vein passes through the Honolulu ground. Its development will be from the Hercules workings, and its acquisition is further evidence of the present policy of the Hercules to take over new properties to replenish the waning ore reserves in the famous old bonanza.

Johannesburg Letter

By John Watson
Special Correspondent

Rand's March Gold Production Beat February by 35,054 Oz.

Average Daily Output 30,603 Oz.—Crown Mines Leads in Production, Government Area in Profit

Johannesburg, April 14—The following crushing results for March, of the leading profit-earning gold mines of the Transvaal, have been published:

	Tons Crushed	Value or Revenue, £	Cost Per Ton Milled s	d	Estimated Profit £
Government Areas	152,000	319,410	17	10.3	186,942
New Modder	117,000	264,487	17	3.0	163,567
Crown Mines	223,000	327,176	19	6.6	109,167
Randfontein Central	219,000	275,999	18	5.4	75,135
Modder Deep	43,800	110,228	16	5.0	74,209
Van Ryn Deep	64,700	140,418	20	9.8	74,069
City Deep	101,500	186,605	22	6.9	72,015
Modder B	68,500	136,704	19	3.2	70,720
Springs	62,700	119,691	22	2.6	61,799
Brakpan	76,000	125,709	20	2.7	61,193
Geduld	71,000	117,419	18	6.0	51,619

The Transvaal gold output for the month of March was declared on April 10 as 795,671 oz. having a value of £3,809,275. This is an increase over February of 35,054 oz., equal in value to £196,344. March contained five Sundays; the daily average output was 30,603 oz., and the price realized for the gold was £4 15s. 9d. per oz. The native labor returns show a decrease of 6,017 natives employed on the gold mines as compared with February.

Meyer & Charlton Gets Part of 120 City Deep Claims

The Meyer & Charlton Gold Mining Co., Ltd., has acquired from the City Deep, Ltd., a part of about 120 claims of the City & Suburban mynpacht adjoining the Meyer & Charlton. This ground could not be worked by the City Deep, Ltd., with advantage; but the area can be attacked from the existing levels of the Meyer & Charlton mine, as it lies between the outcrop of the City and Suburban and the horizon of the lowest level of the Meyer & Charlton.

At the annual meeting of the Transvaal Chamber of Mines held on March 31, Sir Evelyn Wallers, was elected president, for his sixth annual term of office. H. O. Buckle, the retiring president, (who is a barrister), will now act as consultant to the chamber.

In the annual review, reference is made to the adoption of corduroy concentrating tables in place of amalgamated copper plates. The majority of the gold mines of the Rand have now adopted the new method, with beneficial results. Mercurial poisoning should become a thing of the past and the temptation to steal amalgam is reduced to a minimum.

The increase in the recovery of the valuable metals of the platinum group has been interesting. Almost all the mines are now contributing to the production, the bulk of which, however, still comes from the far eastern mines.

Practicing Engineers To Lecture for Arizona University Mining Students

SEVERAL successful mining men have been engaged by the mining school of the University of Arizona to give lectures to students during the next school year, according to announcement made by Dean G. M. Butler. Invitations have been sent to many practicing engineers in Arizona, and replies of acceptance have been received from several. Among those who have signified willingness to prepare lectures for the students are Charles Mitke, consulting engineer, of Bisbee; Arthur Crowfoot, superintendent of concentrators for Phelps Dodge at Morenci; L. E. Weber, chief geologist for United Verde Copper Co., Jerome; Percy Butler, smelter superintendent of Phelps Dodge smelter at Douglas, and D. M. Rait, chief engineer for the Calumet & Arizona company at Bisbee.

Plenty of Miners in Arizona

There is no shortage of mine labor at the various Arizona mining districts, and there seems to have been a greater influx of men during the last month than heretofore. Mining operations are continuing about the same as before the first of the year, the only recent changes in rate of output being that increase which was made at the Magma mine at the beginning of operation of the new smelter.

Most of the larger companies report long rustling lines and, although no increases in working forces are being made, there are many men of the better class available.

Raw Gold! Rough Stuff!

The name of Ten-Mile camp, situated 10 miles west from Winnemucca, Nev., is to be changed to Raw Gold in the district of Ten-Mile. Raw in this instance is a synonym for free, as applied to the occurrence of gold; certainly it sounds realistic. Most of the gold found in this district occurs as leaf and nugget gold, and some very beautiful specimens have been discovered.

Work is being done on two groups of claims, one owned by the See brothers, and one owned by George Clark, and high-grade has been found on both groups and small shipments have been made.

Midwest Plans to Sink Additional 200 Ft. at Butte

A. M. Chisholm, of Duluth, president, and Charles Pfoliot, of St. Paul, vice-president, are inspecting the Midwest property, which is situated in the southwest part of the Butte district, in Montana. The officers are well pleased with the new vein that has been recently opened up. John McBarron, general manager, says that the average value of the new vein is about $40 per ton.

Brisbane Letter

Special Queensland Correspondence to Mining Journal-Press

Cloncurry Lead Field Will Have Sixteen Prospect Shafts

Ore Shipped Amounting to 400 Tons Averaged 65 per Cent Lead, 50 Oz. Silver—Railroad Seems Assured

Brisbane, April 5.—The new silver-lead field (Mount Isa) in the Cloncurry district, is receiving much attention from mining investors, mainly in the southern states of New South Wales and Victoria. Four companies, each with a liberal capital, have been formed, the money wanted in two instances being largely oversubscribed; and two of these concerns have begun work with energy.

The company formed by W. H. Corbould intends to sink eighteen prospecting shafts for a beginning, and when its leases are sufficiently proved will decide on the erection of a treatment plant at a site yet to be selected. Late rains have given a good supply of water on the field, and ore is being conveyed to the railway, for transport to the government smelters at Chillagoe, by motor lorry and horse teams. A total of 400 tons of prospectors' ore, thus forwarded, has returned 65 per cent of lead and 50 oz. of silver per ton.

It has been practically decided to build a branch railway to the new field. Mr. Corbould, who formed the first company to work leases taken up by himself, says the find is the best he has seen since the discovery of Broken Hill.

Cobalt Operations in Full Swing with Ample Water Supply

Much interest is still taken in the rich cobalt mine being developed near Cloncurry. Last year work there was much hampered by dry weather, but difficulties arising from this cause are now over, and crushing is in full swing, with two shifts, which are to be increased to three. In January, 280 tons of ore was raised, and in the last quarter of 1923 there was sent away 2,126 tons, the value of which is given as £25,335, or a little more than £201 per ton. A second cobalt mine is now being worked in the Cloncurry district, on the Dugald River, but no production has yet been reported.

The government has notified the miners at the Anakie sapphire field that about £3,000 worth of gem stones has been sold out of the £20,000 worth held, and that one firm has offered to take the entire output, on which the government has advanced the owners 95 per cent of its value, provided a three years' monopoly is granted and the stone is reclassed on reaching its destination. The local miners are not inclined to favor such a monopoly until they know more about how the classing is to be done and how it would affect prices. Many miners, however, are constantly complaining about the present marketing arrangement, and think they do not get as much for their gems as they should.

Men You Should Know About

Dr. Henry Mace Payne

Dr. Henry Mace Payne will address the American Cotton Manufacturers' Association annual convention at Atlantic City, on May 27, on the subject "Natural Resources and National Problems"; and on June 2 he will deliver the baccalaureate oration at Mississippi A. & M. College, at Starkville, Miss., on "Industry and Citizenship."

S. H. Cathcart is at Jardine, Mont., examining arsenical deposits.

N. O. Lawton, of Salt Lake, is at Lead, S. D., on professional business.

Mark Little has been appointed manager of the Keeley mine, in South Lorrain, Ontario.

Edwin Kirk is making studies of the Rocky Mountain Ordovician rocks near Lander, Wyo.

David White is making collections of Mississippian fossils in southwestern West Virginia.

Henry Hanson, metallurgist, has returned to San Francisco from a short visit from Canada.

Bennett R. Bates, of Mexico City, is in San Francisco. Mr. Bates is planning a visit to South Africa.

C. E. Reed, president of the Reed Roller Bit Co., of Houston, Tex., was in New York on business recently.

F. H. Moffit will make geologic surveys in the Prince William Sound region, Alaska, this summer.

Galen H. Clevenger has returned to Boston from a tour of the zinc smelteries of the United States.

George H. Garrey is in Hamilton, Nev., on professional business connected with the old Treasure Hill mines.

Eugene Dawson has returned to New York from an examination of mining properties in Montana and Mexico.

N. M. Getchell, manager for the Betty O'Neal Mines Co., has returned to the mine from a business trip to Omaha.

H. G. Ferguson has completed a course of six lectures at Johns Hopkins University on geology and metalliferous deposits.

W. Parsons Todd, of New York, vice-president of the Quincy Mining Co., is visiting the properties of the company in the Michigan copper district.

Frank D. Pagluichi arrived in New York on May 13 from Tumeremo, Venezuela, where he has been doing professional examination work. Accompanied by **R. D. Adams**, he returned to Venezuela on May 22.

John H. Hearding, of Duluth, assistant general manager of the Oliver Iron Mining Co., has returned from a business trip to New York and Philadelphia.

C. W. Adams, manager of the East Helena plant of the A. S. & R. Co., has been transferred to the Selby plant and will be assistant to the manager of that plant.

H. W. Edmondson, who is now operating the Rio Plata mine, near Guazapares, Chih., Mexico, was recently in Los Angeles on a short business trip.

M. M. Duncan, of Ishpeming, Mich., vice-president and general manager of the Cleveland-Cliffs Iron Co., has returned to Ishpeming from a trip to California.

Benjamin L. Miller

Benjamin L. Miller, professor of geology at Lehigh University, Bethlehem, Pa., gave an address before the members of the Four-Square Club, Allentown, Pa., on May 7, on the subject of the mining of iron ore.

F. W. Draper, representative in America of the Russo-Asiatic Consolidated, Ltd., of London, is examining mining properties in Mexico for his company.

J. J. Denny, mill manager of the Nipissing company, of Cobalt, Ontario, has resigned his position. Mr. Denny has been connected with the Nipissing for the last sixteen years.

R. B. Lamb, representing Toronto interests, is conducting negotiations having for their object the taking over of the Indian mine, which adjoins the Premier mine, in British Columbia.

James S. Colbath sailed from San Francisco on May 13 on the "President Lincoln" for an extended engagement with the Benguet Consolidated Mining Co. His address will be Baguio, Benguet, Philippine Islands.

G. C. Bateman, formerly manager of the La Rose mines, Cobalt, has been appointed secretary-treasurer of the Ontario Mining Association in succession to **Balmer Neilly**, who recently resigned. Mr. Bateman graduated at Queens University, Kingston, Ont., in 1905 and has had a long experience in mining in the United States and Mexico.

Rear Admiral Hilary P. Jones, Lieutenant Commander Robertson of the U. S. Navy, and **R. D. Bush**, State Mineralogist of California, as members of the special Presidential commission recently appointed to make investigation of the naval oil reserves, arrived in Denver May 13, to secure information concerning the naval oil-shale reservations in western Colorado, which eventually may serve as the final reserve fuel for the Navy.

H. N. Spicer, of the executive staff of The Dorr Company, and Mrs. Spicer will sail on June 4 for London, as the first step in a tour of Europe that will take from four to six months, and will cover practically every important industrial section of the Continent. Mr. Spicer will make a special business survey. He will make his headquarters in London, at 16 South St., E. C., but will spend most of his time in Spain, Italy, Austria, Czechoslovakia, Poland, and Germany.

Obituary

Bart G. Lott, a mining engineer with the Andes Copper Co., died some weeks ago in Chile. Mr. Lott was formerly well known in the West and in Mexico. He was sixty years old.

Henri Knoertzer, mining engineer, who died at Santa Rosalia, Lower California, on Nov. 28, 1923, in his sixty-fifth year, was buried at St. Brieux, Cotes-du-Nord, France, on April 5, 1924.

Charles Edward Major, mining engineer, of Prescott, Ariz., died recently in that city, at the age of sixty-two. Mr. Major was well known in the mountain states, having lived for some years in Colorado before making his home in Prescott, and had attained distinction in his profession. He is survived by his widow, Helen E. Major.

Charles Edward Major

Recent Technical Publications

Reviews, Abstracts, and References

A Phenomenally Good Book on Oil-field Practice

Petroleum Production Engineering. By Lester Charles Uren, Associate Professor of Petroleum Engineering at the University of California. The McGraw-Hill Book Co., New York. Price $6.

Lester C. Uren

California has long been a leader in the study of petroleum production engineering. This is natural, as the problems faced by operators in that section have been more varied than in any other part of the United States. The skill of the rotary drillers in the Gulf Coast fields of Texas and Louisiana is known the world over. Similarly, the oil man thinks of the expert drillers of the Mid-Continent and Eastern areas when the cable system is spoken of.

Within the borders of the two prolific basins to which California owes its position as the foremost oil state in the country will be found the latest developments in the technic of both systems in active use. In addition, California is the mother of the standard circulating system of drilling, which has proved of excellent service in regions where hard dry rocks alternate with soft and water-laden caving ones. California is alone responsible for our knowledge of oil-field hydrology. To its workers can be traced practically every important device now used in the cementing of wells. It has been the leader in concrete reservoir and tank construction. The core barrel for sampling formations is used there to a greater extent than in any other part of the world with the possible exception of South Texas.

The skill which has made possible the rapid development of the gusher pools of the Los Angeles basin is in no small measure due to the knowledge of practical oil-field problems that has been given to its sons by the staff of the university that bears its name. Professor Uren's book is in every way worthy of the university in which he works. Within the 600-odd pages of text will be found very few errors, either of commission or of omission, and the author has included a wealth of material concerning this rapidly growing science that will be found in no other single volume. It is illustrated with nearly four hundred well-chosen tables and figures, which materially increase its value. A point which will recommend it to all engineers is its decided "up-to-dateness." As many of the books appearing on the various phases of the oil business in the last few years have contained much material that had little or no value because of later discoveries and developments, it is decidedly refreshing to pick up a book which, while indicating the strong points of earlier practice, gives full space to the improvements of the last few months.

Professor Uren's volume is divided into twenty chapters. The first two are more or less introductory. They carry the reader through the exploration and leasing stages of oil operations. The third covers the map and cross-section problem in a very thorough manner. Though the engineer may skim this over rapidly it will prove of great value to the layman, who is not infrequently at loss with oil-field maps. The next, called "Developing the Field," might have been better named "Economics of Development," as in it the author points out the problems faced in drilling an area to secure the maximum return.

The last three chapters are given over to discussion of subjects which though not strictly production engineering ones are closely related to the main theme. One covering transportation, while necessarily brief, is complete in its description of pipe-line operations and methods. The chapter on auxiliary plants and departments is too general to be of great value. The same may be said of the last chapter, on office records and methods.

The real meat of the volume will be found in the chapters numbered from five to seventeen. Starting with churn drilling, the author carries his readers through every phase of the production division of the oil industry. His discussions show a clear understanding of the problems of the oil operator and the ability to explain how those problems are being solved in American practice. The clear-cut description of the nature and operation of the several types of fishing devices is especially worthy of careful study. The chapter on oil-field hydrology, and especially the portions dealing with cementing practice, will appeal to eastern and foreign operators. The section on oil-field power is well balanced in the light of present usage, but this reviewer personally would have liked more details on the possibilities of the use of electricity. The discussions on storage and dehydration of crude are indicative of the author's close acquaintance with the California fields in which the most work of this kind has been done.

A bibliography follows each chapter. The reader who requires greater detail is thus enabled to locate the exact place where the material desired will be found, with a minimum of effort. Professor Uren's book is in itself, however, probably the most complete one of its type to be had today. The chapters that have been added to round out the volume add little to its value, but the excellence of the main portion—that dealing with petroleum engineering proper—should commend it to all oil men. It is called a textbook, but I venture the opinion that hundreds of field men will find it of sufficient value to carry in their grips and executives and office men will keep it in full view on their desks. ERNEST R. LILLEY.

Patents

Petroleum—No. 1,490,143. April 15, 1924. F. W. Taber, Duncan, Okla. A method and apparatus for cementing oil wells, comprising a weighted guide line and a plug having a longitudinal aperture to receive the guide line.

No. 1,491,427. April 22, 1924. J. J. Smit, Los Angeles. A method of shutting off water in deep oil wells.

No. 1,491,742. April 22, 1924. C. H. Benckenstein, Vinton, La., assignor of one-fourth to H. R. Eccleston, Washington, D. C., and one-fourth to L. J. Benckenstein, Beaumont, Tex. A rod spacer mechanism for oil wells.

No. 1,492,833. May 6, 1924. G. G. Cecil, Blackwell, Okla. An oil-well drilling rig.

Flotation Reagents — No. 1,490,736. April 15, 1924. H. E. Frederick, Hayden, Ariz., assignor of 23.34 per cent to W. H. Bissell, 23.33 per cent to F. S. Sinnicks, and 53.33 per cent to G. J. Henry, all of San Francisco. Flotation of an ore pulp by the use of an agent which consists substantially wholly of a mixture of the pyridine series of hydrocarbons.

No. 1,491,863. April 29, 1924. T. A. Janney, Garfield, Utah. Flotation by the use of a reagent composed of coal tar oil which has been boiled with an alkaline sulphide.

Crushing Machinery — No. 1,491,897. April 29, 1924. J. M. Blake, Chicago Heights, Ill., assignor to American Manganese Steel Co., Chicago. Design of disks for a disk crusher.

Nos. 1,491,430 and 1,491,431. April 22, 1924. A. H. Stebbins, Los Angeles. Two new forms of jaw crushers.

No. 1,493,998. May 13, 1924. C. S. Lincoln, Wauwatosa, Wis., assignor to Allis-Chalmers Manufacturing Co., Milwaukee, Wis. Design for a gyratory crusher.

No. 1,494,036. May 13, 1924. F. J. Straub, New Kensington, Pa., assignor to Crozier-Straub Inc., New York. A new form of crushing rolls.

Gold Washer—No. 1,491,649. April 22, 1924. Thomas Wiegand, Edmonton, Canada. A gold ore washing device, consisting of a trough with a bottom that is in part perforated, and suitable feeding and receiving pans.

Pneumatic Classifier—No. 1,491,429. April 22, 1924. A. H. Stebbins, Los Angeles. An apparatus for the pneumatic classification of dense and light minerals.

New Machinery and Inventions

MacDonald Cubes as a Grinding Medium

New Patent Produces Interesting Results in Ball and Rod Mills

By D. H. Fairchild
Fairchild & Fairchild, Engineers, Chicago

CRUSHING and grinding bodies used in the reduction of ore in tube and ball mills have generally consisted of so-called "pebbles" of naturally occurring hard rock or of metal, such as iron or steel. In the operation of mills of this character with balls or pebbles approximately spherical in form, the crushing and grinding action is generally limited to points of contact, resulting in loss of efficiency and capacity and undue wear on the grinding bodies.

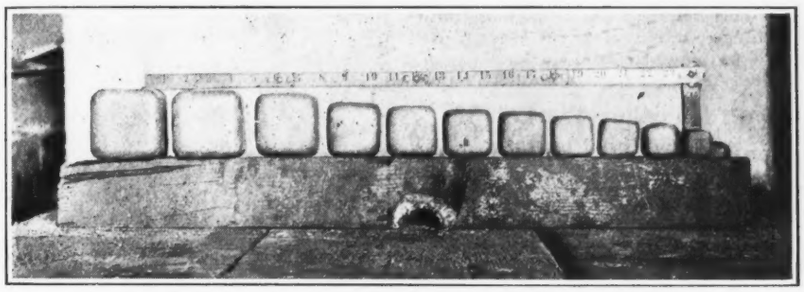


Fig. 1—Eleven cubes showing the gradual reduction by wear and the retention of original shape

The 3-in. cube at left has never been in use. The ten cubes to the right were taken from a 6x12-ft. Marcy rod mill (operating as a cube mill) at the discharge.

In some cases rods of approximately circular cross-section have been used in place of the balls or pebbles, resulting in a tendency toward a line contact between the grinding media.

The purpose of MacDonald cubes is to provide a form of grinding media that, in operation, will present not only point contact and line contact but also a useful contact between approximately plane surfaces. It is believed that this peculiar combination of types of contacts will increase the crushing or grinding effect and at the same time decrease the rate at which the grinding media wear away.

Grinding with balls is effected by the multitude of point contacts between the falling or moving balls. With the energy of the moving ball expended largely at one point of contact, it is quite likely that the particle of material acted upon is often crushed or ground finer than is necessary, the balance of the blow above what would be necessary being not only wasted but the cause of considerable wear upon the grinding medium itself. In a similar manner the type of line contact obtained by the use of rods of circular cross-section probably results in an undue proportion of the energy being expended inefficiently or even injuriously applied.

In the case of the MacDonald cubes the tendency toward surface contact between the adjacent cubes would be to utilize more efficiently the total contained energy in performing useful grinding and crushing action with a minimum portion of that energy being consumed in excessive wear of the cube itself.

It is natural that the first question to enter the mind of the reader should be, "How long will these cubes remain cubes?" Fig. 1 shows ten cubes that were removed from the discharge end of a mill in the concentrator of the Moctezuma Copper Co., at Nacozari, Mexico. These ten cubes were not selected except to secure a gradation in size and they are representative of the entire charge of cubes within that mill. Originally all of the cubes illustrated were 3 in. square, like the one at the extreme left.

Even cubes with defects seem to wear with remarkable regularity. Fig. 2 shows a group of defectives taken from the above-mentioned mill. It will be noted that although the defects occur at the corners, edges, and on the plane surfaces of these cubes, they have retained their original shape. None of the media inspected in the Nacozari mill, however small they had been worn, had lost their identity as cubes.

Unlike balls, the shape of which causes them to be inherently stable in equilibrium, the shape of these cubes causes them to be in a state of unstable equilibrium when in action. This quality of being unstable permits the cube to assume, often, a series of positions that change the type of contact between two or more cubes from, possibly, point to line and then to surface contact in rapid succession, the series being repeated over and over again in one sequence or another as long as the mill revolves. Reference to Fig. 3 will in some measure make plain the types of contacts mentioned.

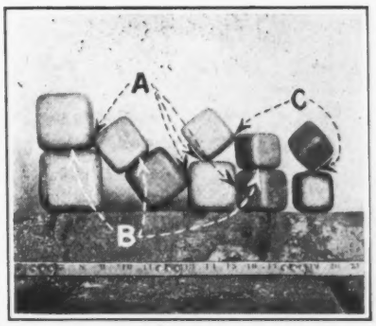


Fig. 3—Various types of contact are illustrated

A, line contact; *B*, surface contact; *C*, point contact

The Moctezuma Copper Co. has been operating two of its 6x12-ft. Marcy roller mills with 3-in. cast MacDonald cubes instead of the usual rods for some time but not long enough to secure complete data. These two rod mills have been changed from low discharge to high-discharge type, but the length and general arrangements are unfavorable to cubes. In spite of these unfavorable conditions the cubes are apparently producing better results than the rods. Fig. 4 shows a pile of the cubes as they come from the foundry. Only cast cubes have been used in the tests so far carried on, but forged steel cubes are now available.

Results of a Test of MacDonald Cubes in Competition With Balls in Ball Mills

	Cast Balls	Cast Cubes
Loss in pounds per ton of ore reduced	1.74	.70
Cost of grinding media per pound	$0.059	$0.058
Cost of grinding media per ton ore reduced	0.0985	0.0385
Kw.-hr. per ton of ore reduced	6.52	4.65
Power cost per ton ore reduced	0.11325	.080770

The above data indicate the results obtained in one test with MacDonald cubes in ball mills. Though the results of a single test are not conclusive proof

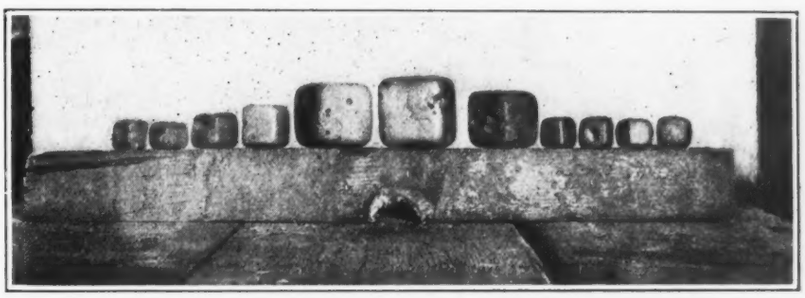


Fig. 2—The cubes retain their shape, even when imperfections are present on edges, corners or faces

Fig. 4—A pile of cubes as they come from the foundry

they certainly indicate that grinding by means of cubes is more efficient than by means of balls and are sufficiently attractive to warrant more careful and complete testing. This is now being done, and in April two cube mills were being operated. A further innovation has recently been tried by modifying the cube shape to that of spheres with six flattened surfaces. Personally, I feel that the regular cube would be likely to give the best results.

The weight of a cubic foot of steel balls when piled in the most compact manner is 363 lb. A cubic foot of these cubes arranged in the most compact form possible would roughly approximate the weight of a cubic foot of steel. In use they naturally arrange themselves so that their cubic foot weight is in excess of that of balls.

A study of the theoretical action of MacDonald cubes gives rise to numerous lines of reasoning that might account for the apparent increase in grinding efficiency that results from their use. It is conceivable that particles of ore would have greater difficulty in escaping the crushing or grinding action of this media than if balls were used. There is ample reason to believe that the energy of a cube is more usefully expended than that of a ball. Fig. 5 indicates to some degree the probable action of both balls and cubes. It will be noted that, unlike the balls, the cubes follow up the crushing or grinding done by points of contact with a "bucking-board" or jaw-crusher action, or, in some instances, a shattering surface-to-surface blow.

The few tests that have so far been operated have apparently verified the theoretical expectations. With the necessity of lowering milling costs so apparent in these days, it would seem logical for more companies to determine what these cubes will do for them in the way of reducing grinding costs.

Fan for Cooling Workers in Industrial Plants

A "man-cooling" fan of improved design intended for use in steel mills, foundries, forges, and other plants where heat-treating processes are used, has recently been introduced by the American Blower Co., of Detroit, Mich. It is made in two sizes, wheels 21¼ in. and 37¼ in. in diameter, operating at 1,725 and 1,120 r.p.m., taking 1 and 4 hp.

According to the manufacturer's description, the fan resembles a desk fan of giant size, and develops a breeze that can be felt over a wide area. It operates at slow speed, which with its sturdiness of construction assures its long life. The fan is known as the Ventura man-cooling fan.

In many industrial plants the need for such a ventilating unit is vital. Heat saps energy—workers become careless—and accidents occur more frequently. Inaccurate work results and material must be rejected because of imperfections. Men seek pleasanter work, and labor turnover is consequently high. It is a recognized fact that production in industrial "hot spots" is seriously hampered by the heat, no matter what the outside weather conditions. Fans are the proved method for ventilating such places.

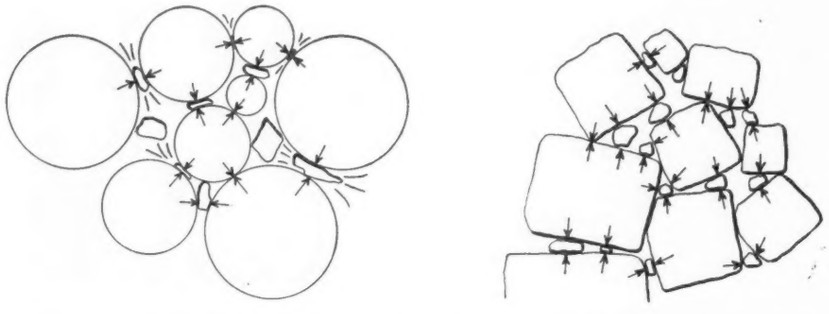
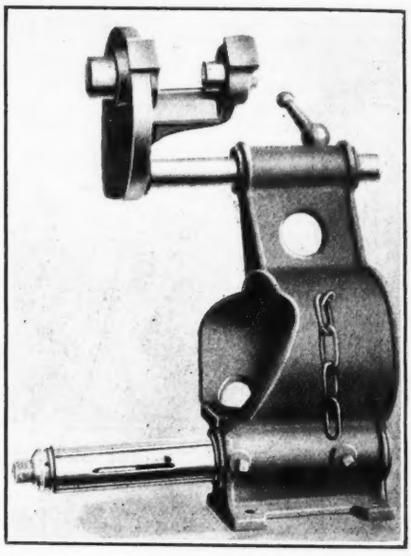


Fig. 5—Showing how, with balls, the particles glance from the point contact, but, with the cubes, are still caught by line and surface contact

Motor Bearings Fitted by New Machine

It is claimed that much time may be saved by using a new combination tool in fitting motor bearings and in testing connecting rods, pistons, wrist pins, and bushings. This machine, which is manufactured by the Elk Machine Tool Corporation, 243 West Seventeenth St., New York, is self-contained, portable and operated by hand. It performs the six different operations necessary for fitting connecting rods, bearings, wrist pins, bushings, and pistons. It weighs 55 lb. and may be carried to any part of a shop, where it may be rigidly bolted to a work bench as desired.



Machine tool for fitting motor bearings and testing

Trade Catalogs

Compressors. Angle compound compressors are covered in bulletin 77-H, 32 pages, issued by the Sullivan Machinery Co., Chicago, Ill. Sullivan angle compound compressors, as at present built, embody tandem wafer valves on all sizes, and three-pass intercoolers with copper intercooler tubes as standard. Straight-line single-stage compressors, belt driven, WG-6 and WH-6, two stage, are covered in bulletin 77-K, 16 pages.

Compressed Air Spaders. Bulletin 70-X, second edition, of the Sullivan Machinery Co., Chicago, Ill., shows new illustrations of these useful clay-digging machines and lists a long-shank spade with double-grip handle for use in open trench digging or similar work.

Vacuum Pumps. Bulletin 78-B of the Sullivan Machinery Co., Chicago, Ill., describes the Sullivan straight-line steam-driven and belt-driven vacuum pumps for vacuum service, equipped with wafer valves.

Pipe Fittings. Leaflet No. 260 of the Steere Engineering Co., Detroit, Mich., describes a pipe joint of the loose-ring Van Stone type. Details are given in Bulletin 38.

The Market Report

Daily Prices of Metals

May	Copper, N. Y. net refinery*	Tin		Lead		Zinc
	Electrolytic	99 Per Cent	Straits	N. Y.	St. L.	St. L.
15	12.75	43.50	44.00	7.175	7.00	5.85
16	12.625	42.50	43.00	7.175	6.90	5.85
17	12.625	41.50	42.00	7.175	6.875	5.825
19	12.625@12.75	40.75	41.25	7.125	6.85	5.80
20	12.50@12 65	40.00	40.50	7.125	6 75	5.75
21	12.50@12.625	41.00	41.50	7.125	6.725	5.70
Av.	12.638	41.542	42.042	7.150	6.850	5.796

*These prices correspond to the following quotations for copper delivered: May 15th, 13.00c.; 16th and 17th, 12.875c.; 19th, 12.875@13.00c.; 20th, 12.75@12.90c.; 21st, 12.75 @12.875c.

The above quotations are our appraisal of the average of the major markets based generally on sales as made and reported by producers and agencies, and represent to the best of our judgment the prevailing values of the metals for deliveries constituting the major markets, reduced to the basis of New York cash, except where St. Louis is the normal basing point, or as otherwise noted. All prices are in cents per pound. Copper is commonly sold "delivered," which means that the seller pays the freight from the refinery to the buyer's destination.

Quotations for copper are for ordinary forms of wire bars, ingot bars and cakes. For ingots an extra of 0.05c. per lb. is charged and there are other extras for other shapes. Cathodes are sold at a discount of 0.125c. per lb.

Quotations for zinc are for ordinary Prime Western brands. Quotations for lead reflect prices obtained for common lead, and do not include grades on which a premium is asked.

The quotations are arrived at by a committee consisting of the market editors of *Engineering and Mining Journal-Press* and a special representative of the Bureau of Mines and the Bureau of Foreign and Domestic Commerce.

London

May	Copper			Tin		Lead		Zinc	
	Standard		Electro-lytic						
	Spot	3M		Spot	3M	Spot	3M	Spot	3M
15	61 3/8	62 1/4	67 1/4	219 1/2	218 7/8	29 5/8	28 1/2	31	31 1/4
16	60 7/8	61 3/4	66 1/2	214 3/4	214 1/4	29 1/2	28 1/2	30 7/8	31 1/8
19	62	62 7/8	67 1/4	206	205 1/2	29 1/8	28	30 5/8	30 7/8
20	61 3/4	62 5/8	67 1/4	201 1/2	201	28 3/4	27 3/4	30 1/2	30 5/8
21	61 1/2	62 3/8	67	206 1/2	206 1/4	28 3/4	27 3/4	30 3/8	30 1/2

The above table gives the closing quotations on the London Metal Exchange. All prices in pounds sterling per ton of 2,240 lb.

Silver, Gold, and Sterling Exchange

May	Sterling Exchange "Checks"	Silver		Gold London	May	Sterling Exchange "Checks"	Silver		Gold London
		New York	London				New York	London	
15	4.36 1/4	65 1/8	33 9/16	94s 6d	19	4.36 3/8	66	34	94s 6d
16	4.36 1/4	65 3/8	33 11/16	94s 7d	20	4.35 1/2	66 1/2	34 5/16	94s 8d
17	4.36 1/2	65 5/8	33 13/16	.....	21	4.35 3/4	66 5/8	34 3/8	94s 9d

New York quotations are as reported by Handy & Harman and are in cents per troy ounce of bar silver, 999 fine. London silver quotations are in pence per troy ounce of sterling silver, 925 fine. Sterling quotations represent the demand market in the forenoon. Cables command one-quarter of a cent premium.

Metal Markets

New York, May 21, 1924

It has been a poor week for the nonferrous metals. The principal ones all declined in price, both in London and New York. Silver has been the only bright spot and has moved to a new high for the year on the strength of London and Far Eastern buying. The weaker tendency of the copper, zinc, lead and tin markets is partly ascribed to the passage of the bonus bill in Congress, but there is no doubt that a slowing of business in general is also directly responsible.

Some stimulus is needed to counteract the easier business conditions in this country and the depressed feeling of manufacturers in various lines. The metal markets are always quick to feel a slackening in trade.

Copper

Copper was sold yesterday and today for 12.75c. delivered. This is a drop of nearly a quarter of a cent during the week. Business has been light, although inquiries have at times been quite numerous. On the strength of a rise in the London price the New York copper market took on a better aspect last Monday, but a slight advance in price was unsustained and the market declined further. Most of the sales that were made during the week brought 12⅞c. per lb. Some lots on Thursday were sold for 13c. delivered. The purchases of one important consumer had a steadying effect upon the market for a short time. Eastern refineries are reported to be behind in May shipments of copper.

The foreign situation looks better than for several weeks past, and sales are more frequent now that the elections are over in Germany and France. Increased consumption abroad would aid the market greatly. No complaint can be made about the volume of business going to domestic consumers, despite the fact that some of them report a slight falling off in their orders. In a declining market, however, consumers are not expected to be interested actively in buying. They show a deeper interest in forward metal, that is for July, August, and September shipment than for prompt.

Lead

On Thursday, May 15, the American Smelting & Refining Co. reduced its official contract price from 7.50c. to 7.25c. per lb. New York.

The outside market has dropped almost daily. St. Louis has been the center of weakness, one or two sellers pressing metal for sale continually. Whereas earlier in the week, lead in the Middle West could be sold for 7c. per lb., today it can be obtained in fair sized quantities for 6.725c. Consumers are well covered for their requirements, so far as prompt metal is concerned. Inquiries have been chiefly for June shipment. In fact, the bulk of the outside business has been transacted for June. Some manufacturers consider lead at 7 to 7.25c. still too high to stimulate their sales. Purchases of pig lead have been lighter during the last week than for several months. At least one producer has declined to follow the market down and instead prefers to accumulate a stock at prices below 7c. St. Louis.

In New York very little May lead was sold. Sales were confined to June and July shipment. Last Thursday June lead was sold as low as 7c. in the East.

Zinc

The market for Prime Western zinc, after showing some buoyancy, has again declined, carrying the price down to 5.70c. per lb. today. With the exception of a few sales of moderate size earlier in the week, the market has been exceedingly quiet. Galvanizers have simply stayed out of the market completely, owing, it is thought, mainly to a falling off in their business. Smelters maintain that they cannot make both ends meet at present prices. It is reported that one smelter in the Middle West is to shut down, and another is to curtail production sharply. A drop in output would have a bene-

ficial effect upon the market, and there is a slight indication that the mines are decreasing production.

High-grade zinc business has been good, with prices holding at 7¾ to 8¼c. per lb., depending upon delivery point. The New York Prime Western zinc market is 35 points above St. Louis.

Tin

New orders in the tin market have been practically nil. Dealers have been the chief participants in the market, and came in strongly yesterday, anticipating the advance that occurred today. Prices have fallen so drastically that consumers have lost confidence in the market. Yesterday Straits tin was almost back to the 40c. level.

Arrivals of tin, May 1 to 19, 2,870 long tons.

Foreign Exchange

On Tuesday, May 20, closing cable quotations on francs were 5.34c.; lire, 4.435c.; and Canadian dollars, 1⅝ per cent discount.

Silver

The London market has been strong and advancing the last week, on Continental buying, supported by buying for India and China account, the London closing quotation today being 34⅜d., which is the highest price touched this year. The future of the market depends on the continuation of Continental buying.

Mexican Dollars — May 15th, 49⅝; 16th, 49¾; 17th, 50⅛; 19th, 50⅜; 20th, 50¾; 21st, 50⅞.

Other Metals

Quotations cover large wholesale lots unless otherwise specified.

Aluminum—99 per cent grade, 28@29c. per lb.; 98 per cent, 27@28c. London, £125 per long ton.

Antimony—Per lb.:
Chinese and Japanese brands, 8¾@9c.
W. C. C. brand, 11½@12c.
Cookson's "C" grade, 12½@13c.
Chinese needle, lump, nominal, 8½@9c.
Market slightly higher.

Bismuth—$2.35@$2.40 per lb. London, 10s.

Cadmium—60c. per lb. London, 2s. 8d.

Cobalt—$2.50@$3 per lb. for spot.

Iridium—$275@$300 per oz.

Nickel—27c. per lb. for 99 per cent virgin metal. London, £135 long ton.

Osmiridium—Crude, $58.50 per oz.

Palladium—$83 per oz. Crude, $60 per oz.

Platinum:
Refined, $116 per oz.
Crude, $112@$113 per oz.
Market dull. Inquiries and offerings very light. Prices holding well.

Quicksilver — $76@$77 per 75-lb. flask. San Francisco wires $72.65; London, £13¼.

The prices of Magnesium, Molybdenum, Monel Metal, Osmium, Radium, Rhodium, Selenium, Tellurium, Thallium, and Tungsten are unchanged from prices given in May 3 issue.

Metallic Ores

Chrome—$19@$22, depending upon grade and source. Nominal.

Manganese—42@46c. per long ton unit, seaport, c.i.f. Nominal.

Molybdenum—80c. per lb. of MoS_2 for 85 per cent concentrates. Nominal.

Tungsten Ore—Per unit, N. Y.
High-grade wolframite, $9@$9.25.
High-grade scheelite, $9.25.
Ordinary grades, $8.60@$8.75. Nominal.

Iron Ore, Magnetite, Tantalum, and Vanadium are unchanged from May 3 quotations.

Zinc and Lead Ore Markets

Joplin, Mo., May 17—Zinc blende, per ton, high, $42.80; basis 60 per cent zinc, premium, $40; Prime Western, $39; fines and slimes, $38@$36; average settling price, all zinc ores, $37.89.

Lead, high, $104.50; basis 80 per cent lead, $80; average settling price all lead ore, $91.83 per ton.

Shipments for the week: Blende, 12,249; lead, 1,611 tons. Value, all ores the week, $611,940.

Three mining companies have closed down, each a group of mines, cessation at which is lowering production. Smelting companies are buying light, and loading more each week than is purchased, until the sold stock in the bins is less than 12,000 tons, against a high figure of 36,000 tons of sold ore the first week of March.

Platteville, Wis., May 17—Blende, basis 60 per cent zinc, $41 to $42.25 per ton. Lead, basis 80 per cent lead, $90 per ton. Shipments for the week: Blende, 651 tons; lead, 30 tons. Shipments for the year: Blende, 9,896; lead, 352 tons. Shipments for the week to separating plants, 1,326 tons blende.

Non-Metallic Minerals

Asbestos:
Crude No. 1—$300@$400.
Crude No. 2—$175@$225.
Spinning fibers—$90@$150.
Magnesia and compressed sheet fibers—$60@$90.
Shingle stock—$50@$70.
Paper stock—$35@$40.
Cement stock—$20@$25.
Floats—$10@$12.
All per short ton, f.o.b. mines, Quebec, tax and bags included.

Diatomaceous Earth—Per ton, f.o.b. plant, California:
Powder, insulation, $30.
Aggregate, natural, $20.
Aggregate, calcined, $50.
Brick, kiln fired, $60.
Filtration powder, $30.

Barytes, Bauxite, Beryl, Borax, Chalk, China Clay, Emery, Feldspar, Fluorspar, Fuller's Earth, Garnet, Gilsonite, Graphite, Gypsum, Ilmenite, Limestone, Magnesite, Manjak, Mica, Monazite, Ocher, Phosphate, Pumice, Pyrites, Rutile, Silica, Sulphur, Talc, Tripoli and Zircon are unchanged from May 3 prices.

Mineral Products

Arsenious Oxide (white arsenic)—10c. per lb., nominal. Market dull.

Copper Sulphate—4.90@5c. per lb. Demand recently improved.

Potassium Sulphate, Sodium Sulphate, Sodium Nitrate and Zinc Oxide are unchanged from the May 3 prices.

Ferro-Alloys

Ferrochrome, Ferromanganese, Ferromolybdenum, Ferrosilicon, Ferrotitanium, Ferrotungsten, Ferro-uranium and Ferrovanadium are unchanged from the prices given in the May 3 issue.

Metal Products

Copper—Sheets, 20¼c. base; wire, 15¼c.

Lead Sheets—Cut, 11½c.; full, 11¼c. per lb.

Nickel Silver—18 per cent Grade A sheets, 26¼c.

Yellow Metal—Dimension sheets, 17¾c.; rods, 14¾c.

Zinc Sheets—Base price, $9.50 per 100 lb., f.o.b. plant.

Refractories

Bauxite Brick, Chrome Brick, Firebrick, Magnesite Brick, Magnesite Cement, Silica Brick and Zirkite are unchanged from the May 3 prices.

The Iron Trade

Pittsburgh, May 20, 1924

The volume of general buying of steel products has not decreased noticeably. There is, however, a further decrease in the volume of fabricated steel business. The steadiness of prices becomes weekly of more moment, as declines lately have been almost insignificant, and with a few further readjustments, in lines which have not declined as have the heavy rolled products, the market may find itself on a stable basis.

Bars, shapes, and plates are if anything steadier than a fortnight ago at 2.20c.@2.30c. Shading of the old prices on wire products by $2 a ton is more common. Independent sheet mills are selling in many cases at $5 a ton under the leading interest's schedule, the movement toward a $4 cut from old prices not having worked out. Pipe mills are holding prices rigidly, but in some quarters an early reduction is positively predicted.

Tin plate is inactive, buyers not being interested in third-quarter. By reason of the backward season, cans are not moving as expected and mill stocks accordingly have not moved, current production, at about 80 per cent of capacity, being shipped.

Steel production is scarcely decreasing, being at about two-thirds of the recent peak rate and about 20 per cent under the average rate of 1923.

Pig Iron.—Foundry iron goes so commonly at $21, Valley, that this is the principal market, rather than the old $21.50 figure, which is still obtained on carloads. Bessemer is off 50c. at $22, Valley, basic remaining nominal at $21, Valley. The market remains quiet.

Connellsville Coke.—There is no demand for furnace coke, and odd lots have forced prices down to $3.50@$3.60, and foundry coke is off 25c. at $4.50@$5. Production has been decreasing still more sharply in the last two or three weeks.

Company Reports

Yukon Gold Co.

The Yukon Gold Co. had a deficit of $421,909.48 after depletion and depreciation in 1923 as follows:

Statement of Income

	Year 1923 Cubic Yards	Production	Working Costs	Operating Gain
Dawson dredge	447,601	$141,787.53	$122,089.90	$19,697.63
Dawson hydraulics	1,320,360	197,842.24	134,716.35	63,125.89
California dredge	444,857	23,684.08	19,187.04	4,497.04
Murray dredge	1,321,626	244,802.77	88,063.24	156,739.53
Malay dredges	1,159,800	272,205.39	296,001.86	(a) 23,796.47
Friendship silver-lead operations		64,672.35	41,813.13	22,859.22
Miscellaneous operations		8,422.19	253.80	8,168.39
Total operations		$953,416.55	$702,125.32	$251,291.23
Non-operating income				128,330.83
Total income				$379,622.06
Less				
Royalties and interest			$330,460.65	
Depletion			117,151.27	
Depreciation			264,019.62	
Net deficit for 1923				$421,909.48

(a) Loss.

As forecast in the last annual report, dredging operations in California and the Yukon Territory have been discontinued. There is still some hydraulic ground in the Dawson district to be mined; and one dredge is operating in Idaho on the property leased from the Coeur d'Alene Mining Co. The principal holdings of the company, however, upon which work is being actively prosecuted at this time, are the dredging areas in the Federated Malay States, the Nevada lode mines, and the Mayo silver-lead properties.

In regard to the Malay tin project, the new dredges met with difficulties which were not anticipated and which prevented profitable operation. These difficulties have been largely overcome, and both dredges are now on a paying basis. Engineers' reports show that the company's Malay properties contain a large quantity of high-grade ground: also that, in some instances, they present difficult dredging conditions.

In August, 1923, a subsidiary corporation, the Ampang Tin Co., Ltd., was formed, and took over the entire acreage included in the Yukon Gold Co., Ampang-Salak project, comprising approximately 3,900 acres, or over half of the Malay acreage controlled by Yukon Gold Co. The Ampang Tin Co., Ltd., of which Yukon Gold Co. owns 90 per cent, was organized in compliance with an agreement made with the minority interests at the time the Ampang-Salak properties were acquired.

In the Nevada lode mines, the development work of the last year added ore sufficient for two years' operations, and the outlook is favorable for still further extension of the known orebodies.

Copper Range Co.

Copper Range had an operating income of $248,117.33 before depletion and depreciation in 1923 as follows:

23,571,360 lb. produced and sold @ 14.808c.		$3,490,565.64
Interest		185,515.87
Atlantic Mining Co.		11,682.48
		$3,687,763.99
Mining and other expenses		2,797,158.47
		$890,605.52
Taxes		307,859.59
		$582,745.93
Copper Range R.R. Co.		34,807.39
		$617,553.32
Deduct one-half of net mining profit of Champion Copper Co., which belongs to St. Mary's Mineral Land Co.		369,435.99
Operating income		$248,117.33
Depletion and depreciation for two and one-half mines	$711,543.49	
Trimountain shutdown expense	107,320.80	818,864.29
Deficit		$570,746.96

Net excess of assets amounts to $5,015,449.39.

Comparative Statement

Baltic Tri-Mountain and One-half Champion Combined

	1923	Average for Ten Years 1914 to 1923 Inclusive
Tons of rock stamped	368,639	786,165
Pounds of refined copper produced	14,365,045	25,481,510
Pounds of refined copper per ton stamped	38.96	32.28
Cost of copper per pound including depreciation and depletion	$0.1907	$0.1584
Price received per pound	0.14808	0.1934
Profit per pound	0.0426—loss	0.0350

Dividends totaling $394,425 were paid in 1923.

Kennecott Copper Corporation

Kennecott Copper in its report for 1923 shows a net balance earned before depletion and depreciation of $8,249,413.52 as follows:

Income Account

Operating revenue		
Copper sold, 50,945,719 lb. @ 14.896c.		$7,588,722.80
Silver sold, 378,572.46 oz. @ 80.587c.		305,081.24
Insurance received on ore and concentrates lost in transit		449,909.65
		$8,343,713.69
Operating cost		
Mining and milling	$2,565,595.64	
Treatment, refining, and freight	2,148,947.30	
Selling and delivery charges	225,355.70	
General expense	361,606.90	5,301,505.54
		$3,042,208.15
Income from miscellaneous operations at mines		28,485.53
Profit on metals sold		$3,070,693.68
Distributions received on securities owned	$4,486,786.33	
Interest, discount and miscellaneous	2,092,443.01	6,579,229.34
		$9,649,923.02
Deduct—Interest and taxes		1,400,509.50
Balance to earned surplus		$8,249,413.52

Earned Surplus

Balance as stated Dec. 31, 1922		$15,304,985.40
Income for year as above		8,249,413.52
		$23,554,398.92
Depreciation on construction and equipment	$237,526.07	
Depletion	4,305,486.76	
Capital distributions from Utah Copper Co.	4,281,741.00	8,824,753.83
Balance of earned surplus Dec. 31, 1923		$14,729,645.09

Balance sheet as of Dec. 31, 1923, is given as follows:

Statement of Assets and Liabilities Dec. 31, 1923

Assets

Property accounts		$10,904,591.48
Investments		
1,245,206 shares Utah Copper Co.	$92,062,171.20	
2,566,781 shares Braden Copper Mines Co	39,489,560.56	
34,237,725 shares Alaska Steamship Co.	3,683,362.50	
500 shares Alaska Development & Mineral Co.	62,480.03	
1 share Copper Export Asso. Inc. stock	1.00	
48,174 shares C.R.& N.W. Railway Co. stock	1.00	
23,020,000 par value C.R.& N.W. Railway Co. bonds	14,984,108.34	150,281,684.63

Liabilities

Capital	$159,244,412.08
Ten-year 7 per cent bonds	15,000,000.00
Accounts payable	1,187,620.66
Earned surplus (after deducting depletion)	14,729,645.09
	$190,161,677.83

Cost of producing copper was 8.356c. per lb. delivered to consumer after depreciation, taxes, and silver credits.

Pursuant to authorization of the stockholders at a special meeting held on April 9, 1923, the authorized stock of the corporation was increased from 3,000,000 to 5,000,000 shares and an offer was made to the holders of outstanding stock of the Utah Copper Co. to exchange their stock for stock of the Kennecott Copper Corporation upon the basis of 1¼ shares of Kennecott stock for one share of Utah stock. At the end of the year 628,702 additional shares of Utah Copper Co. had been acquired, making a total of 1,245,206 shares owned by the Kennecott Corporation at Dec. 31, 1923, or 76.65 per cent of the entire outstanding capital stock of the Utah Copper Co.

Anaconda Copper Mining Co.

Anaconda's report for 1923 shows a net income of $8,767,814.20. Four dividends of 75c. each per share were declared. Production was as follows:

	Copper, Lb.	Lead, Lb.	Zinc, Lb.	Silver, Oz.	Gold, Oz.
Reduction works	215,107,226	.....	.....	9,279,770	30,063.5
Great Falls plants	205,807,887	16,837,089	144,374,819	3,750,530	6,012.3
Raritan plant	398,294,865	.....	.....	20,643,095	98,913.5
International smelter (Cu)	31,056,440	.....	.....	1,831,917	18,371
International smelter (Pb.)	.....	63,538,500	.....	4,495,478	10,153
Miami smelter	189,900,983	.....	.....	608,503	7,507
International refinery	.....	97,118,093	.....	6,945,450	20,328

Arsenic production, 5,932,428 lb.; phosphate rock (32.6 per cent), 31,521.2 tons; brass, copper and nickel-silver, 505,518,834 lb.

Though the volume of business was the largest in the company's history, the low price for copper that prevailed during the latter half of the year made it impossible to realize earnings commensurate with the business done.

Consolidated Balance Sheet Dec. 31, 1923

Assets

Mines, lands, deposits and water rights	$125,672,943.70	
Buildings and machinery	105,422,847.52	
Investments in sundry companies	98,831,465.78	
		$329,927,257.00
Deferred charges and discount on bonds		13,866,933.39
Supplies on hand, etc.	$18,742,836.74	
Metals and manufactured products in process	46,402,342.61	
Accounts receivable	21,131,529.96	
Marketable securites	8,408,082.00	
Cash	7,859,933.93	102,544,725.24
		$446,338,915.63

Liabilities

Capital stock		
Authorized, 6,000,000 shares of $50 each		
Issued 3,000,000 shares		$150,000,000.00
Minority interests in subsidiary companies		2,045,216.16
Bonds outstanding		
First consolidated mortgage 6 per cent	$106,981,000.00	
7 per cent convertible debentures	50,000,000.00	
Ten-year 6 per cent Series A	16,938,000.00	
		173,919,000.00
Reserve for depreciation		30,459,238.20
Current		19,864,011.70
Surplus		
Balance Dec. 31st, 1922	$71,284,784.48	
Adjustments	1,001,149.11	
	$70,283,635.37	
Net income for 1923	8,767,814.20	
	$79,051,449.57	
Deduct four dividends	9,000,000.00	70,051,449.57
		$446,338,915.63

Consolidated Income Account

Expense

Metals and manufactured products in process and on hand at beginning of year		$43,672,792.54
Ores and metals purchased		46,569,192.77
Mining, reduction and refining of metals		43,324,427.15
Manufacturing expenses, including selling		74,662,321.24
Cost of merchandise sold and operation of public service companies		2,433,772.24
Administration and federal taxes		1,147,767.30
Balance carried down		16,026,516.94
		$227,836,790.18
Depreciation and obsolescence		$3,822,893.51
Interest, including discount on bonds, less income from marketable securities		9,830,294.29
Balance		
Carried to balance sheet	$8,767,814.20	
Apportioned to minority interests (loss)	8,138.85	8,759,675.35
		$22,412,863.15

Income

Sales of metals and manufactured products	$171,282,495.62
Tolls, royalties and rentals	7,232,771.56
Sales of merchandise and revenue from public service companies	2,919,180.39
Metals and manufactured products in process and on hand at end of year	46,402,342.61
	$227,836,790.18
Balance brought down	$16,026,516.94
Income from investments in sundry companies	6,386,346.21
	$22,412,863.15

Ahumada Lead Co.

Silver-lead; Los Lamentos, Chih., Mexico.

Ahumada Lead Co. paid dividends of $118,701.80 from 1923 operations according to a report of operations of the company for 1923. Shipment of ore on a small scale was begun from the Ahumada property in May, and during the year a total of 19,345 dry tons of ore was shipped to the El Paso smelter. The net returnable lead was 9,680,299 lb., and 120,277 oz. of silver was paid for at the market price.

A regular dividend of 7½c. and an extra dividend of 2½c., or a total of 10c. per share, or $118,701.80, was declared at the end of the year, payable Jan. 2, 1924.

Consolidated Balance Sheet

Assets

Cash on hand and in banks	$46,461.85	
Accounts receivable	50,790.46	
		$97,252.31
Metal inventory	132,226.33	
Prepaid expense	1,825.24	
		134,051.57
Mining claims and equipment	568,035.51	
Erupcion Mining Co. stock	558,470.65	
Chihuahua & Oriente Rr. stock	296,250.00	
		1,422,756.16
Total		$1,654,060.04

Liabilities

Accounts payable	$217,838.43
Reserves, surplus and legal reserve	249,203.61
Capital stock	1,187,018.00
Total	$1,654,060.40

Braden Copper Co.

Copper; Chile

A total of $7,209,402.06 before depletion and depreciation was earned by the Braden Copper Co. for 1923 as follows:

Combined Statement of Income

Operating revenue		
Copper sold and delivered—138,168,080 lb. @ 14.760c	.....	$20,394,292.10
Gold and silver	.....	60,718.22
		$20,455,010.32
Operating cost		
Plant cost	$8,651,962.12	
Freight to seaboard	532,838.41	
Embarking ocean freight and insurance	443,829.79	
Refining	1,173,351.44	
Delivery and selling expenses	417,433.21	11,219,414.97
Operating profit	.....	$9,235,595.35
Other income	.....	43,713.95
Total income	.....	$9,279,309.30
Charges against income (taxes and bond interest)	.....	2,069,907.24
Net income for year—carried to surplus account	.....	$7,209,402.06

Combined Statement of Surplus Account

Deficit, Dec. 31, 1922—adjusted	.....	$5,643,959.58
Net income as above	.....	7,209,402.06
		$1,565,442.48
Charges against surplus, 1923		
Depletion	$3,119,835.24	
Depreciation	2,111,035.89	
Loss on plant and equipment	32,885.87	
Amortization of discount on bonds	128,461.56	
	$5,392,218.56	
Less discount on bonds	4,155.00	5,388,063.56
Deficit, Dec. 31, 1923	.....	$3,822,621.08
Depletion reserve, Dec. 31, 1923	.....	13,320,029.53
Net combined Surplus and Depletion Reserve, Dec. 31, 1923	.....	$9,497,408.45

Combined Statement of Assets and Liabilities Dec. 31, 1923

Assets

Property, construction, and development	.....	$37,326,041.79
Investment—Sherman Steamship Co.	.....	575,480.13
Unamortized discount on bonds	.....	899,230.66
Bond deposit account	.....	255,000.00
Current and working assets	.....	8,899,181.72
		$47,864,934.30

Liabilities

Capital stock issued—Braden Copper Mines Co.	.....	$12,953,530.00
Bonds issued—15 year 6 per cent sinking fund	.....	10,724,000.00
Kennecott Copper Corporation loan account	.....	11,500,000.00
Kennecott Copper Corporation bond loan account	.....	255,000.00
Loan from subsidiary company	.....	100,000.00
Accounts payable and miscellaneous	.....	2,834,995.85
Net deficit from operations	$3,822,621.08	
Depletion reserve	13,320,029.53	9,497,408.45
		$47,864,934.30

The entire plant was operated at full capacity through 1923. There was mined and milled during the year 3,857,000 tons of ore, with a total smelter output of blister copper of 139,531,048 lb. The report records a steady and consistent reduction in operating costs.

Freight Rates on Metals, Ores, and Concentrates

Carload Lots

Copper Bullion and Refined Copper

From	To	Rate per Ton of 2,000 Lb. All Rail	Via Gulf
El Paso, Tex.	Baltimore, Md.	$11.40	$10.00
Garfield, Utah	Perth Amboy	12.50	.....
Garfield, Utah	San Francisco	5.85	.....
Hayden, Ariz.	Perth Amboy	14.50	12.50
Miami, Ariz.	Perth Amboy	14.50	12.50
Anaconda, Mont.	Perth Amboy	12.50	.....
Butte, Mont.	Perth Amboy	12.50	.....
Humboldt, Ariz.	Chrome, N. J.	14.50	12.50
Douglas, Ariz.	Perth Amboy	14.50	12.50
Globe, Ariz.	Perth Amboy	14.50	12.50
Clifton, Ariz.	Perth Amboy	14.50	12.50
Clarkdale, Ariz.	Chrome, N. J.	14.50	12.50
Copperhill, Tenn.	Laurel Hill, N. Y.	$10.80	.....
Tooele, Utah	Chrome, N. J.	12.50	.....
McGill, Nev.	Baltimore, Md.	15.90	.....
Houghton, Mich.	New York	(a) 9.60*	.....
Hancock, Mich.	New York	(a) 9.60*	.....
Hubbell, Mich.	New York	(a) 9.60*	.....
Dollar Bay, Mi h.	New York	(a) 9.60*	.....
Tacoma, Wash.	New York via Canal	Conference rate	$6.00
Anaconda, Mont.	Tacoma, Wash.	7.09	.....
Ajo, Ariz.	New York	14.50	$12.50

(a) Applies April 1 to Nov. 30.

Marine Freight Rates

New York to
- Hamburg — $4.00 per gross ton copper and lead
- Liverpool — $4.00 per gross ton copper and lead
- Antwerp — $3.50 per gross ton copper and lead
- Havre — $3.75 per gross ton lead; $4.25 per gross ton copper

Gulf ports to
- Hamburg — $4.00 per gross ton copper and lead
- Liverpool — $4.00 per gross ton copper and lead
- Antwerp — $3.50 per gross ton copper and lead
- Havre — $4.25 per gross ton copper

Pacific coast ports to
- Hongkong — $6.00 per short ton
- Kobe — $6.00 per short ton

Tampico to
- Liverpool Bremen, Hamburg, Rotterdam
- Havre — $4.50 per metric ton
- Dunkirk — $6 per metric ton

Lead Bullion; (Pig Lead Where Shown)

From	Rates per Ton of 2,000 Lb. To New York	To St. Louis
East St. Louis, Ill.	$7.00	.....
Pueblo, Colo.	14.15	$9.65
Leadville, Colo.	(c) 12.50	(c) 9.50
East Helena, Mont	(c) 12.50	(c) 9.50
El Paso, Tex.	10.00 Via Gulf	
	(c) 12.00 All Rail	* 7.00
Omaha, Neb.	9.60	3.65
Murray, Utah	(c) 12.50	(c) 9.50
Midvale, Utah	(c) 12.50	(c) 9.50
Tooele, Utah	(c) 12.50	(c) 9.50
East Chicago, Ill.	6.40	(a) 2.00
Kellogg, Idaho	(c) 13.50	(c) 9.50
Carnegie, Pa.	3.80	(a) 5.00
Selby, Calif.	(d) 6.00	.....
Herculaneum, Mo.	(a) 8.80	(a) 1.80
Federal, Ill.	7.00	(a) 1.80
Collinsville, Ill.	7.00	(a) .75½
Granby, Mo.	(a) 10.50	(a) 3.50
Joplin, Mo.	(a) 10.50	(a) 3.50

(a) Pig lead only.
(c) Note—Reduced rates effective:
Montana to seaboard, March 15
Utah to seaboard, Feb. 29
Idaho to seaboard, March 15
Leadville to seaboard, Feb. 29
(d) Conference rate, via canal.

Slab Zinc

From	Rates per Net Ton to E.St. Louis	New York
Donora, Pa.	(a) $4.60	$3.80
Langeloth, Pa.	(a) 4.60	3.80
Palmerton, Pa.	7.10	3.00
Hillsboro, Ill.	1.40	7.00
Danville, Ill.	2.00	6.40
La Salle, Ill.	2.00	6.70
Springfield, Ill.	3.00	7.00
Cleveland, Ohio	5.80	5.00
Moundsville, W. Va.	4.40	3.80
Van Buren, Ark.	3.80	10.80
Fort Smith, Ark.	3.80	10.80
Bartlesville, Okla.	3.50	10.50
Blackwell, Okla.	3.80	10.80
Henryetta, Okla.	3.80	10.80
Sand Springs, Okla.	3.80	10.80
Cherryvale, Kan.	3.50	10.50
Black Eagle, Mont.	9.40	12.50
Park City, Utah	9.00	12.50

(a) To St. Louis, Mo.

Zinc Ores and Concentrates

To	From	Rate per Net Ton
Bartlesville, Okla.	Altoona, Kan.	$2.10
	Pittsburg, Kan.	1.09
	Galena, Kan.	1.30
	Joplin, Mo.	1.40
	Iola, Kan.	1.09
	Baxter, Kan.	1.40
	Miami, Okla.	1.40
	Quapaw, Okla.	1.40
	Kansas City, Mo.	1.60
Sand Springs, Okla.	Miami, Okla.	2.20
	Quapaw, Okla.	2.20
	Galena, Kan.	1.50
	Joplin, Mo.	1.50
	Iola, Kan.	2.40
Dewar, Okla.	Cave Springs, Mo.	2.00
Kusa, Okla.	Cent City Spur, Mo.	2.00
Henryetta, Okla.	Chitwood, Mo.	2.00
	Galena, Kan.	1.50
	Iola, Kan.	2.40
	La Harpe, Kan.	2.40
La Harpe, Kan.	Mound City, Kan.	.50
	Oswego, Kan.	.50
	Parsons, Kan.	.50
Coffeyville, Kan.	Galena, Kan.	1.10
	Joplin, Mo.	1.22
Bartlesville, Okla. (a)	Baxter, Kan.	1.80
	Miami, Okla.	1.80
	Quapaw, Okla.	1.80

(a) Lead ore and concentrates.

Rates on Ores and Concentrates

From	To	Value of Product: $5	$10	$15	$20	$25	$30	$35	$40	$50	$60	$70	$75	$80	$90	$100
		Rate														
Butte, Mont.	Anaconda, Mont.	.17	.17	.17	.17	.17	.17	.17	.17	.17	.17	.17	17	.17	.17	.17
Butte, Mont.	Black Eagle, Mont. (a)	....	....	....	....	....	....	....	1.01	....	....	....	....	....	....	....
Great Falls, Mont.	East Helena, Mont.	....	....	1.57	....	1.76	....	1.98	....	2.43	....	....	....	....	....	2.55
Butte, Mont.	East Helena, Mont.	....	....	1.17	....	1.46	....	1.69	....	2.03	....	....	....	....	....	2.14
Paxton, Calif.	Salt Lake Smelters, Utah	....	....	....	....	....	....	....	....	6.30	7.00	7.70	....	8.35	8.60	8.85
Johannesburg, Calif.	Selby, Calif.	....	....	....	2.90	....	3.50	....	4.10	4.70	5.30	5.90	....	6.50	6.80	7.10
Johannesburg, Calif.	Humboldt, Ariz.	....	....	....	3.40	....	4.10	....	4.80	5.50	6.20	6.90	....	7.60	8.00	8.30
Fioche, Nev.	Humboldt, Ariz.	....	4.50(c)	7.74	....	8.55	....	9.36	....	9.99	....	....	11.25	....	....	12.42
Creede, Colo.	Durango, Colo.	....	....	3.25	3.50	3.75	4.00	....	4.25	4.75	5.25	5.75	6.05	....	....	7.10
Ouray, Colo.	Durango, Colo.	....	....	4.30	4.80	....	5.05	....	....	5.90	....	6.30	....	....	....	7.70
Kokomo, Colo.	Durango, Colo.	....	6.00	....	....	6.50	7.20	....	....	....	....	....	....	....	....	....
Telluride, Colo.	Durango, Colo.	....	....	....	....	....	4.30	....	5.00	*5.50	*6.00	6.30	....	*6.60	*7.10	7.70
Silverton, Colo.	Durango, Colo.	....	....	1.40	1.40	....	....	2.20	....	....	2.30	2.55	....	2.80	....	2.80
Tyrone, N. M.	Douglas, Ariz.	....	....	1.60	1.90	....	2.20	....	2.50	2 80	....	..	3 40	....	....	3.80
Tyrone, N. M.	El Paso, Tex.	....	....	1.60	1.90	....	2.20	....	2.50	2 80	....	..	3 40	....	....	3.80
Lordsburg, N. M.	Douglas, Ariz.	....	1.00	1.30	1 60	....	1.90	....	2.20	2 50	....	....	2.80	....	....	3.40
Lordsburg, N. M.	El Paso, Tex.	....	1.00	1.30	1.60	....	1.90	....	2.20	2.50	....	....	2.80	....	....	3.40
Tombstone, Ariz.	Douglas, Ariz.	....	....	.60	....	.90	....	....	....	.30	....	....	.60	....	....	1.90
Tombstone, Ariz.	El Paso, Tex.	....	....	1.90	....	2.50	....	....	....	3.80	....	....	.40	....	....	4.40
Silver City, N. M.	Douglas, Ariz.	....	....	2.48	....	3.15	....	....	....	3.83	....	....	....	....	....	5.29
Ray Junction, Ariz.	Hayden, Ariz.	....	.10	....	.40	....	.50	....	.80	.90	....	....	.00	....	....	1.10
Sandon, B. C. / Alamo Concentrator, B. C.	Tadanac, B. C.	1.50	1.60	1.70	1.90	2.00	2.50	....	2.60	2 90	3.40	3.50	....	3.70	3.80	3.90
Rossland, B. C.	Tadanac, B. C.	.90	.90	1.00	1.00	1.10	1.50	....	1.60	1.60	1.60	1.70	....	1.70	1.70	1.70
Rossland, B. C.	Tadanac, B. C(d).	.30	.30	.30	.30	.50	.70	....	.80	.80	....	....	....	....	....	....
Republic, Wash.	Tadanac, B. C.	....	2.02	2.50	2.66	2.86	3.84	....	3.84	3.84	4.69	4.89	....	5.19	5.39	5.59

(a) Minimum tonnage of 200 tons per day. (b) In open cars, minimum 80,000 lb. (c) Siliceous ore tailing.
(d) Applicable on ore, only when shipped in trainload lots of not less than 10 cars and exclusive of switching charges at Rossland.

From	To	Value of Ores and Concentrates: $10	$15	$20	$25	$30	$35	$40	$50	$60	$70	$75	$80	$90	$100
		Rate													
Burke, Idaho	Bradley, Idaho	....	....	....	....	....	....	....	....	.68	....	.....	....	....	1.02
Burke and Wallace, Idaho	East Helena, Mont.	....	....	....	....	3.00	....	3.25	3.50	3.75	4.00	.....	4.25	4.50	4.75
Sagel, Idaho	East Helena, Mont.	....	....	....	3.38	....	3.83	....	4.16	....	....	.....	....	.....	4.84
Arizona Tunnel, Idaho	Bradley, Idaho	....	....	....	....	....	....	....	....	.35	....	.....	....	.....	.50
Bayview, Idaho	Bradley, Idaho	....	....	....	....	....	....	....	3.75	....	....	4.37½	....	.....	5.12½
Park City, Utah	Salt Lake Smelters	1.00	1.10	1.25	....	1.50	....	1.75	....	2.00	....	.....	2.25	....	2.50
Eureka, Utah	Salt Lake Smelters	1.00	....	1.25	....	1.50	....	1.75	2.00	2.25	2.50	.....	2.75	3.00	3.25
Tintic, Utah	Salt Lake Smelters	1.00	....	1.25	....	1.50	....	1.75	2.00	2.25	2.50	.....	2.75	3.00	3.25
St. Johns, Utah	Salt Lake Smelters	1.00	....	1.25	....	1.50	....	1.75	2.00	2.25	2.50	.....	2.75	3.00	3.25
Ophir, Utah	Salt Lake Smelters	1.00	....	1.25	....	1.50	....	1.75	2.00	2.25	2.50	.....	2.75	3.00	3.25
Bingham, Utah	Garfield, Utah	....	.40	....	.75	....	....	....	.95	....	....	1.10	....	....	1.25
Cherry Creek, Nev.	Garfield, Utah (c)	....	....	4.60	....	5.10	....	5.60	6.10	6.60	7.10	.....	7.60	8.10	8.60
Cherry Creek, Nev.	Garfield, Utah (b)	....	....	3.20	....	3.90	....	4.60	5.30	6.00	6.70	.....	7.40	....	....
Goldfield, Nev.	Salt Lake Smelters	....	....	5.10	....	5.80	....	6.50	7.20	7.90	8.60	.....	9.30	10.00	10.70
Battle Mountain, Nev. (a)	Salt Lake Smelters	....	4.15	3.20	....	3.80	....	4.40	5.00	5.60	6.20	.....	6.80	7.40	8.00
Palisade, Nev. (a)	Salt Lake Smelters	....	*2.90	3.20	....	3.80	....	4.40	5.00	5.60	6.20	.....	6.80	7.40	8.00
Mina, Nev. (a)	Salt Lake Smelters	....	....	3.60	....	4.30	....	5.00	5.70	6.40	7.10	.....	7.80	8.50	9.20
Lovelock, Nev. (a)	Salt Lake Smelters	....	....	3.20	....	3.90	....	4.60	5.30	6.00	6.70	.....	7.40	8.10	8.80
Golconda, Nev. (a)	Salt Lake Smelters	....	....	3.20	....	3.90	....	4.60	5.30	6.00	6.70	.....	7.40	8.10	8.80
Hasen, Nev. (a)	Salt Lake Smelters	....	....	3.20	....	3.90	....	4.60	5.30	6.00	6.70	.....	7.40	8.10	8.80
Tonopah, Nev.	Salt Lake Smelters	....	4.15	5.10	....	5.80	....	6.50	7.20	7.90	8.60	.....	9.30	10.00	10.70
Rogerson, Idaho	Salt Lake Smelters	3.00	....	3.50	....	4.00	....	4.50	5.00	5.50	6.00	.....	6.50	7.00	7.50
Georgetown, Colo.	Leadville, Colo.	....	....	3.50	....	3 75	....	4.00	5.00	5.00	5.80	.....	5.80	5.80	5.80
Shirley, Colo.	Leadville, Colo.	....	....	2.25	....	2.25	....	2.25	2.25	4.30	4.30	.....	4.30	4.30	4.30

(a) Minimum weight, marked capacity of car used, but not less than 80,000 lb. (b) Minimum weight, 80,000 lb. (c) Minimum weight, 40,000 lb.
* Indicates a change of tariff since last report.

Mining Stocks

Week Ended May 17, 1924

Stock	Exch.	High	Low	Last		Last Div.
COPPER						
Alaska-Br. Col.	N. Y. Curb	...	...	*15	...	...
Anaconda	New York	32¼	29⅞	29¾	Dc.15, Ja.21, Q	0.75
Arcadian Consol.	Boston	1 1/16	1	1	...	...
Ariz. Com'l.	Boston	8⅝	8½	1½	Ja.15, Ja.31	0.50
Calaveras	N. Y. Curb	1⅜	1⅜	1⅜	...	...
Calumet & Arizona	Boston	46	45	45½	Mc 7, Mc.24, Q	0.50
Cal. & Hecla (New)	Boston	14½	13⅝	13⅞	De. 1, De. 17	0.50
Canario Copper	N. Y. Curb	2¼	2	2¼	...	...
Cerro de Pasco	New York	45½	44½	44½	Ap. 17, My. 1	1.00
Chile Copper	New York	28⅛	27⅜	27⅞	Jn.2, Jn.30, Q	0.62½
Chino	New York	16¼	15⅞	15⅞	Sept., 1920,	0.37½
Con. Coppermines	N. Y. Curb	2⅜	2	2	...	...
Copper Range	Boston	21	20¼	20½	May, 1923	1.00
Crystal Copper	Boston Curb	69	58	58	...	...
Davis-Daly	Boston	*56	*46	*48	Mar., 1920	0.25
East Butte	Boston	4¼	4¼	4¼	Dec., 1919	0.50
First National	Boston Curb	27	27	27	Feb., 1919,	0.15
Franklin	Boston	*70	*70	*70	...	...
Gadsden Copper	Boston Curb	*42	*40	*42	...	...
Granby Consol.	New York	13	13	13	May, 1919	1.25
Greene-Cananea	New York	12⅞	10	10	Nov., 1920	0.50
Hancock	Boston	†1	...	...	...	...
Howe Sound	N. Y. Curb	2⅝	2½	2⅝	Ap.1, Ap.15, Q	0.05
Inspiration Consol.	New York	24½	22⅝	23	De.20, Ja.7, Q	0.50
Iron Cap	Boston Curb	2⅞	2½	2½	May, 1923	0.15
Isle Royale	Boston	14⅜	13	13⅜	Se. 1, Se. 15,	0.50
Jerome Verde Dev.	N. Y. Curb	*98	*95	*98	...	...
Jib Consol	N. Y. Curb	*41	*15	*28	...	...
Kennecott	New York	38⅝	37½	37⅞	Mc.7, Ap. 1, Q	0.75
Keweenaw	Boston	*50	*50	*50	...	...
Lake Copper	Boston	1¼	1	1	...	...
Magma Copper	New York	31⅜	29⅝	29⅝	Jan., 1919	0.50
Mason Valley	N. Y. Curb	1⅞	1½	1⅝	...	...
Mass Consolidated	Boston	*60	*60	*60	Nov., 1917	1.00
Miami Copper	New York	22	21⅜	21½	My. 1, My. 15, Q	0.50
Mohawk	Boston	*28	*27	*27	Se. 22, Oc. 13,	1.00
Mother Lode Coa.	New York	7⅞	6¼	6⅝	De.14, De.31	0.50
Nevada Consol.	New York	13	13	13	Sept., 1920,	0.25
New Cornelia	Boston	18⅝	18⅛	18⅛	My.9, My.26,	0.25
New Dominion	N. Y. Curb	2⅛	2⅛	2⅛	...	...
North Butte	Boston	2⅝	2⅝	2⅝	Oct., 1918,	0.25
Ohio Copper	N. Y. Curb	*84	*76	*82	...	...
Old Dominion	Boston	18⅞	18½	18⅛	Dec., 1918	1.00
Phelps Dodge	Open Mar.	†117	...	...	Mc.24, Ap.2 Q	1.00
Quincy	Boston	16⅛	15⅛	15⅜	Mar., 1920	1.00
Ray Consolidated	New York	9⅞	9⅜	9⅝	Dec., 1920	0.25
Ray Hercules	N. Y. Curb	...	...	*14	...	...
St. Mary's Min. Ld.	Boston	29	28	28⅛	Ap.22, My.20	3.00
Seneca Copper	New York	1	15/16	15/16	...	...
Shannon	Boston	*35	*35	*35	Nov., 1917	0.25
Shattuck Arizona	New York	5½	5	5	Jan., 1920	0.25
Superior & Boston	Boston	*60	*60	*60	...	...
Tenn. C. & C. cfs.	New York	7	6⅜	6⅞	De.31, Ja.15, Q	0.25
Utah Copper	New York	67⅛	66⅜	67⅝	Mc.14, Mc.31, Q	1.00
Utah Metal & T.	Boston	*30	*25	*30	Dec., 1917	0.30
Victoria	Boston	*65	*65	*65	...	...
Walker Mining	N. Y. Curb	3 3/16	2⅞	2⅛	...	...
Winona	Boston	†*16	...	...	...	...
NICKEL-COPPER						
Internat. Nickel	New York	11⅞	11⅜	11⅝	Mar., 1919	0.50
Internat. Nickel pfd.	New York	76	76	76	Ap.17, My.1, Q	1.50
LEAD						
Carnegie Lead & Zinc	Pittsburgh	2⅜	2¼	2¼	...	...
National Lead	New York	130¼	128	130	Jn.13, Jn.30, Q	2.00
National Lead pfd.	New York	114½	114½	114½	My. 23, Ju. 14, Q	1.75
St. Joseph Lead	New York	24¼	23⅜	24¼	Mc. 20, 1924	0.50
ZINC						
An. Z. L. & S.	New York	7⅛	7⅛	7⅛	May, 1920	1.00
Am. Z. L. & S. pfd.	New York	26½	26⅛	26½	Nov., 1920	1.50
Butte C. & Z.	New York	4¼	4⅛	4⅛	Ma., 1923	0.50
Butte & Superior	New York	15½	14⅜	14⅛	Je.15, Je. 30, Q	0.50
Callahan Zn-Ld.	New York	3⅜	3⅜	3⅜	Dec., 1920	0.50
New Jersey Zn.	N. Y. Curb	139	136½	138⅛	May 10, 1924	2.00
United Zinc	N. Y. Curb	...	...	*25	...	...
Yellow Pine	Los Angeles	72½	69¾	69¼	Mar., 1924	0.04
SILVER						
Alvarado	N. Y. Curb	...	...	1	...	...
Beaver Consol.	Toronto	*21⅛	*19	*19	May, 1920	0.03
Castle-Trethewey	Toronto	*73⅜	*66	*66½	...	...
Coniagas	Toronto	...	...	1.90	Ap.20, My.1	0.02½
Crown Reserve	Toronto	*56½	*54½	*54½	Jan., 1917	0.05
Keeley	Toronto	2.21	2.17	2.21	...	...
Kerr Lake	N. Y. Curb	1⅜	1⅜	1⅜	Ap.1, Ap.15, Q	0.12
La Rose	Toronto	*15	*11	*11	Apr., 1922	0.10½
Lorrain Trout Lake	Toronto	†1.32	†1.28	1.35	...	...
McKinley-Dar.-Sav.	Toronto	*12¼	*11¼	*12	Oct., 1920	0.03
Mining Corp. Can.	Toronto	†3.03	†2.99	2.95	Sept., 1919	0.12½
Nipissing	N. Y. Curb	6	6	6	Mc.1, Ap.21, Q	0.03½
Ontario Silver	New York	...	...	6	Jan., 1919	0.50
Temiskaming	Toronto	*24	*22	*22	Jan., 1920	0.40
GOLD						
Alaska Gold	New York	...	...	⅛	...	...
Alaska Juneau	New York	1¼	1¼	1¼	...	...
Argonaut	Toronto	*49½	*44	*45	...	...
Carson Hill	Boston	1	1⅛	1⅛	...	...
Cresson Consol. G	N. Y. Curb	3⅛	3⅛	3⅛	Mc.3, Ap.10, Q	0.10
Dome Mines	New York	15⅞	15⅝	15½	Mc.26, Ap.21, Q	0.50
Golden Cycle	Colo. Springs	1.34½	1.34½	1.34½	My.31, Jn.10 Q	0.03
Hollinger Consol.	Toronto	†12.80	†12.55	12.90	My. 1, My. 19	0.05
Homestake Mining	New York	49½	49⅛	49⅛	My.10, My.26,	.50
Kirkland Lake	Toronto	*21	*20	*20½	...	...
Lake Shore	Toronto	3.75	3.73	3.75	My.2, My.15	0.02
McIntyre-Porcupine	New York	15⅝	15⅜	15½	Ap. 1, My. 1,	0.25
Newray	Toronto	†*30	†*26½	*26	...	...
Portland	Colo. Springs	59	59	59	Oct., 1920	0.01
Teck-Hughes	Toronto	1.18	1.14	1.16	...	...
Tom Reed	Los Angeles	36	34½	34½	Dec., 1919	0.02
Tough-Oakes	Toronto	†*66	†*64	63	...	...
United Eastern	N. Y. Curb	*62	*58	*59	Ap 10, Ap.28, Q	0.10
Vipond Cons.	Toronto	1.09	1.04	1.06	...	...
Wright-Hargreaves	Toronto	3.00	2.95	2.95	Mc.15, Ap. 1, Q	0.02½
GOLD AND SILVER						
Black Oak	N. Y. Curb	*70	*68	*70	...	...
Con. Cortez	N. Y. Curb	38	35	38	...	...
Con. Virginia	San Francisco	5½	5½	5½	...	...
Continental Mines	N. Y. Curb	...	...	2½	...	...
Dolores Esperanza	N. Y. Curb	...	...	*50	Jy. 1, Jy. 10 Q	0.05
Premier Gold	N. Y. Curb	2	2	2	Mc.28, Ap.5	0.08
Tonopah Belmont	N. Y. Curb	*55	*35	*35	Apr., 1923	0.05
Tonopah Divide	N. Y. Curb	*20	*17	*19	Se.22, Oc. 10	0.10
Tonopah Extension	N. Y. Curb	2⅜	2 3/16	2⅜	Mc. 11, Ap. 1	0.05
Tonopah Mining	N. Y. Curb	1⅞	1⅞	1⅞	Ap. 6, Ap. 21	0.07½
Unity Gold	N. Y. Curb	1¼	1	1⅛	...	...
West End Consol.	N. Y. Curb	*50	*50	*50	Mar., 1923	0.05
Yukon Gold	N. Y. Curb	*60	*60	*60	June, 1918	0.02
SILVER-LEAD						
Ahumada	Boston Curb	5¾	5¾	5¾	Mc., Ap. 2, X	0.15
Bingham Mines	Boston	15	15	15	Sept, 1919	0.25
Cardiff M. & M.	Salt Lake	...	...	*84	Dec., 1920	0.15
Chief Consol.	Boston Curb	3½	3⅜	3½	Ap 19, My. 1, Q	0.10
Columbus Rexall	Salt Lake	26	23	26	Aug., 1922	0.03
Consol. M. & S.	Montreal	41¾	38	40¾	Oct., 1920	0.62½
Daly Mining	Salt Lake	...	...	205	July, 1920	0.10
Erupcion	Boston Curb	2⅛	2⅛	2⅛	Mc. 15, Ap.2, X	0.15
Federal M. & S.	New York	8½	8½	8½	Jan., 1909	1.50
Federal M. & S. pfd.	New York	43⅞	42¾	43⅜	My.26, Jn.15, Q.	1.75
Florence Silver	Spokane	11½	10	11½	Apr., 1919, QX	0.01
Hecla Mining	N. Y. Curb	9	8⅞	8⅞	My.15, Jn.15,	0.25
Iron Blossom Con.	N. Y. Curb	*26	*26	*26	Oct., 1923	0.02
Marsh Mines	N. Y. Curb	*7	*7	*7	June, 1921	0.02½
Park City	Salt Lake	4.00	4.00	4.00	Mar., 1924	0.15
Park Utah	N. Y. Curb	...	...	3½	Mc.15, Ap.1	0.15
Prince Consol.	Salt Lake	...	...	*75	Nov., 1917	0.02
Silver King	N. Y. Curb	*3	*3	*3	Ap. 1, X	0.30
Silversmith	Spokane	40⅞	40⅛	40⅛	My. 1, My. 10	0.01
Tamarack-Custer	Spokane	1.88	1.75	1.75	Se.30, Oc. 1, K	0.02
Tintic Standard	Salt Lake	3.97½	3.90	3.97½	Mar. 25, 24, QX	0.15
Utah-Apex	Boston	2⅛	2¼	2⅛	June, 1923,	0.50
IRON						
Bethlehem Steel	New York	48⅝	46⅜	47⅛	Jn.1, Jy.1, Q	1.25
Char. Iron	Detroit	⅝	9/16	⅝	...	...
Char. Iron pfd.	Detroit	...	...	1	...	...
Colorado Fuel & Iron	New York	41¼	36⅜	39⅝	My.10, My.26	Q 2.00
Col. Fuel & Iron pfd.	New York	...	...	102	Feb., 1923	2.00
Gt. North'n Iron Ore	New York	27⅛	27	27⅛	De.10, De.27	2.00
Inland Steel	N. Y. Curb	...	...	46	My.15, Jn.1	Q 0.62½
Mesabi Iron	N. Y. Curb	2⅝	2⅛	2¼	...	...
Replogle Steel	New York	8	7⅞	8	...	...
Republic I. & S.	New York	45	43¼	44⅛	May, 1921	1.50
Republic I. & S. pfd.	New York	...	...	86	Mh.20, Ap.1	QX 2.75
Sloss-Sheffield S. & I.	New York	55¼	54	55	Feb., 1921	1.50
Sloss-Shef. S. & I. pfd.	New York	...	...	80	De.20, Ja.2, Q	1.75
U. S. Steel	New York	97⅛	95¼	96⅞	Jn.1, Jn.28	QX 1.75
U. S. Steel pfd.	New York	119	118½	119	My.6, My.29,	Q 1.75
Virginia I. C. & C.	New York	43	43	43	De.15, Ja. 2	1.50
Virginia I.C.&C.pfd.	New York	...	...	74	De.15, Ja.22	2.50
VANADIUM						
Vanadium Corp.	New York	22	21¼	21¼	Jan., 1921	1.00
ARSENIC						
Western Utah Copper	N. Y. Curb	25	25	25	...	...
ASBESTOS						
Asbestos Corp.	Montreal	...	...	27	Se.29, Oc.15	Q 1.00
Asbestos Corp. pfd.	Montreal	...	...	55	Ap.1, Ap.15,	Q 1.50
SULPHUR						
Freeport Texas	New York	9½	8½	8¾	Nov., 1919,	1.00
Texas Gulf	New York	60⅜	58¼	60	My.31, Jn.14	QX 1.75
PLATINUM						
So. Am. Gold & P.	N. Y. Curb	3½	3¼	3⅜	...	...
MINING, SMELTING AND REFINING						
Amer. Metal	New York	40½	39	40½	My.20, Jn.1, Q	0.75
Amer. Metal pfd.	New York	110⅜	108½	109½	My.20, Jn.1, Q	1.75
Amer. Sm. & Ref.	New York	7⅛	7⅛	7⅛	Ap. 1, My. 1, Q	1.25
Amer. Sm. & Ref. pfd.	New York	26½	26¼	26⅛	My. 9, Jn. 1,	1.75
U. S. Sm. R. & M.	New York	21	20	20½	Jan., 1921,	0.50
U. S. Sm. R. & M. pfd.	New York	...	...	40	Apr., 1924, Q	0.87½

* Cents per share. † Bid or asked. Q, Quarterly. SA, Semi-annually. M, Monthly. K, Irregular. I, Initial, X, Includes extra. The first date given is that of the closing of the books; the second that of the payment of the dividend.

Boston quotations courtesy Boston Stock Exchange; Toronto quotations those of the Standard Stock Exchange of Toronto, by courtesy of Arthur E. Moysey & Co.; Spokane, Pohlman Investment Co.; Salt Lake, Stock and Mining Exchange; Colorado Springs, Colorado Springs Stock Exchange.